The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

DISPOSITION INSTRUCTIONS

Destroy this report when it is no longer needed.
Do not return it to the originator.

AD B058048

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARCSL-TR-80068	2. GOVT ACCESSION NO. AD-B058 048	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) THE SUBCHRONIC EFFECTS OF REPEATED EXPOSURE TO WHITE PHOSPHORUS/FELT SCREENING SMOKES IN RATS		5. TYPE OF REPORT & PERIOD COVERED Technical Report July 1978–May 1980 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Bernard J. Brown, Garnett E. Affleck, Edmund G. Cummings, Richard L. Farrand, William C. Starke, John T. Weimer, Muhammed S. Ghumman, SP5, Ronald J. Pellerin		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Commander/Director, Chemical Systems Laboratory ATTN: DRDAR-CLB-T Aberdeen Proving Ground, Maryland 21010		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Project 1M162622A554 Technical Area 4-5
11. CONTROLLING OFFICE NAME AND ADDRESS Commander/Director, Chemical Systems Laboratory ATTN: DRDAR-CLJ-R Aberdeen Proving Ground, Maryland 21010		12. REPORT DATE May 1981 13. NUMBER OF PAGES 129
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE NA

16. DISTRIBUTION STATEMENT (of this Report)

Distribution limited to US Government agencies only because of test and evaluation; May 1981. Other requests for this document must be referred to Commander/Director, Chemical Systems Laboratory, ATTN: DRDAR-CLJ-R, Aberdeen Proving Ground, Maryland 21010.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Smoke
White phosphorus
Felt
Screening smoke
Subchronic toxicity
Rats
White phosphorus/felt

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Toxicity studies were conducted to determine the subchronic effects of repeated exposure to three concentration levels of a white phosphorus screening smoke. When white phosphorus burns, it forms a number of oxides of phosphorus which are rapidly converted by moisture to phosphorus and phosphonic acids. It would appear that the chance of injury is high at 1161 mg/m^3 and low at 193 mg/m^3. At 589 mg/m^3, one-half of the rats showed some exposure effects. The rats apparently developed a tolerance to repeated exposures, particularly at the lowest level.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

1/2

PREFACE

The work described in this report was authorized under Project 1M162622A554, Chemical Munitions and Chemical Combat Support; Technical Area 4-5, Smoke Toxicology. The work was started in July 1978 and completed in May 1980. The experimental data are contained in notebook 9839.

In conducting the research described in this report, the investigators adhered to the "Guide for the Care and Use of Laboratory Animals" as promulgated by the Committee on Revision of the Guide for Laboratory Animals Facilities and Care of the Institute of Laboratory Animal Resources, National Research Council.

The use of trade names in this report does not constitute an official endorsement or approval of the use of such commercial hardware or software. This report may not be cited for purposes of advertisement.

Acknowledgment

The authors wish to acknowledge the following:

Clarence E. Hopkins for the performance of gross necropies and body-organ weight data.

John F. Miller and Franklin Tittle for preparation of blood samples for chemical analysis and statistical analyses of the results.

Malcom N. Allison, CPT, V.C., for histopathology. These data are included verbatim as appendixes.

William Lane for his technical assistance.

CONTENTS

THE SUBCHRONIC EFFECTS OF REPEATED EXPOSURE TO WHITE PHOSPHORUS/FELT SCREENING SMOKES IN RATS

1. INTRODUCTION

Toxicity studies were conducted to determine the subchronic effects of repeated exposure to three concentration levels of a white phosphorus screening smoke. This smoke, one of the candidate screening smokes, was generated by burning pieces of white phosphorus-impregnated felt.

The following studies were performed to obtain a subchronic toxicity profile on rats: inhalation toxicity of multiple exposures, including pathology, hematology, and blood chemistry, and effects of exposures on reproduction, behavior, and physiology.

2. EXPERIMENTAL PROCEDURES

2.1 Chamber operation and sample collection.

Animals for the inhalation studies were placed in compartmented stainless-steel wire-mesh cages. The cages were put on racks in a 20-cubic-meter exposure chamber.

Military grade white phosphorus, which had been forced under pressure into thick pieces of wool felt, was cut into cubes having specific weights. For each exposure, one of these cubes on an aluminum foil pan of a known weight was placed on an electric hotplate within the chamber. The hotplate was a fast-heating unit capable of temperatures in excess of 700°F.

The chamber door was closed and sealed, and the chamber exhaust system was shut down. The hotplate was plugged in and the white phosphorus/felt ignited, usually in less than 2 minutes, producing a dense white smoke. This smoke is made up of a number of oxides of phosphorus: $P_4O{\cdot}P_2O{\cdot}P_2O_3$ (or P_4O_6), PO_2 (or P_2O_4), P_2O_5 (or P_4O_{10}), and P_2O_6; but only three of these species - P_2O_3, PO_2, and P_2O_5 - are well established.[1] All three of these oxides are deliquescent and they could, therefore, contribute various aqueous droplets to the smoke. The reaction of P_2O_5 with atmospheric moisture has already been described; the corresponding reaction for P_2O_3 produces o-phosphorus acid. The tetraoxide, P_2O_4, reacts with water to produce equimolar solutions of o-phosphorous and o-phosphoric acid.[1] The white phosphorus/felt burning time ranged from less than 1 minute for some of the small cubes to over 9 minutes for one of the large cubes. The smoke was contained within the chamber for 15 minutes before being removed by the exhaust system.

Smoke sampling started after 7 minutes of exposure. The samples were collected on Gelman Type-A glass fiber filter pads. Twelve liters of chamber air, at the rate of 3 liters per minute, were drawn through the filter pads contained in the air sampler probe. The filter pads were placed in Erlenmeyer flasks. Particulate material was extracted with distilled water, boiled for 10 minutes, and titrated for phosphoric acid content (see appendix A).

Air samples were also collected in a modified Rochester cascade impactor and analyzed for phosphoric acid content, and the mass median diameter of the airborne particles was derived.

2.2 Animals used.

Four groups of Sprague-Dawley rats were used, one for each dose level plus the controls. Thirty-six male and 36 female rats were used for the high- and intermediate-exposure levels with 18 rats of each sex acting as controls for each level. Only 18 males and a like number of females were exposed to the low-dose level. Nine animals of each sex acted as controls for this exposure.

Additional groups of rats were exposed and the rats were mated on different schedules to determine the effects of repeated exposures on mammalian germ cells and reproductive performance. Procedures used are discussed in a previous report.*

2.3 Animal exposures and observations.

Animals were exposed for 15 minutes daily, 5 days a week for 13 weeks. The rats were observed for toxic signs before and after each exposure. At regular intervals during the 13-week exposure and 4-week postexposure periods, all animals were weighed.

After 6 weeks, one-third of the animals were withdrawn from exposure. Half of these animals were bled and submitted to pathology. The other half were examined to see if any physiological or behavioral changes occurred. When the 13 weeks of exposure ended, the remaining animals were separated into two groups. One group was divided as were the 6-week animals with half going to pathology and half for physiological and behavioral studies. The remaining animals were held for a 4-week postexposure period to observe any recovery that might occur. Then they were bled and submitted for pathological evaluation.

2.4 Blood studies.

Blood samples in rats were analyzed for triglycerides, cholesterol, glucose, urea nitrogen, creatinine, uric acid, sodium, potassium, chloride, carbon dioxide, alkaline phosphatase, albumin, globulin, calcium, phosphorus, serum glutamic pyruvic transaminase, serum glutamic oxalacetic transaminase, red blood cell count, white blood cell count, differential white blood cell count, hematocrit, and hemoglobin.

2.5 Pathology.

Gross and microscopic pathological examinations of the following body organs were performed for all animals submitted: heart, lung, liver, spleen, kidney, brain, eye, trachea, nasal turbinate, adrenal, stomach, urinary bladder, pancreas, thyroid, esophagus, duodenum, colon, lymph node, thymus, testis, epididymus, ovary, uterus, bone marrow, and skin. In addition to those animals sacrificed at 6, 13, and 17 weeks, animals that died during the experiments were submitted for necropies. The number sacrificed at each time interval was adjusted according to the number of animals that died during that interval.

---

*Starke, W. C., and Pellerin, R. J. Technical Memorandum. The Effects of CS-2 on Reproduction in Rats (in preparation). 1980.

2.6 Physiological and behavioral studies.

Animals were submitted for physiological and behavioral evaluations using the procedures described in a previous publication.[2]

3. RESULTS

3.1 Exposure conditions.

Target concentrations were 1000, 500, and 200 mg/m^3. Target and actual concentrations are used interchangeably in the appendixes. Concentrations are also referred to as high, intermediate, and low, respectively. To obtain desired concentrations, 20-, 10-, or 3-gram cubes of the white phosphorus-impregnated felt were used. When ignited, a dense white smoke-like mist was produced. The droplets of this mist had a mass median diameter of 0.5 micron. A charred residue weighing approximately 27% of the original weight remained after burning.

Appendix B, table B-1, shows the mean exposure doses produced by each cube recorded.

3.2 Toxic signs.

Animals were not visible for observation until the smoke cloud was evacuated from the chamber. Visible toxic signs were not observed during the first 3 days of exposure to the high dose. One hour after the fourth exposure one female rat died. Two other rats wheezed for about 2 hours. Of the 72 rats starting this high-dose study, 23 died during the first 6 weeks of exposure. Four more died during the remaining 7 weeks. Transitory dyspnea and wheezing were observed in many rats, with recovery within 2 hours of each exposure. The cumulative exposures at which deaths occurred are shown in appendix B, table B-2.

Rats exposed to the intermediate and low doses showed no visible toxic signs. None of these animals died.

3.3 Body-organ weights.

There were no consistent changes in total body weights or in weights of the organs regardless of dose or time. Means and standard errors for body and organ weights of control and exposed rats are shown in tables B-3 and B-4, appendix B. Significant differences, where they did occur, are indicated.

3.4 Hematology and blood chemistry.

No agent-related changes were observed in the blood chemistry and hematology analyses. "T" test evaluations indicated there were no significant agent-related differences between control and exposed values. No sex-related changes were observed. Means and standard errors of all blood constituents analyzed are shown in tables B-5 through B-10, appendix B.

3.5 Pathology.

3.5.1 Spontaneous deaths.

A high mortality rate (about 40%) occurred in the group of colony rats exposed to the 1161 mg/m^3 dose level. The deaths appear to be agent and dose related. None of the rats exposed to the intermediate- or low-dose levels died. A complete description of pathological findings is presented in appendix C.

3.5.2 Six-week exposure.

Although laryngitis or tracheitis was not observed in any of the control animals, all laryngeal and tracheal specimens from rats exposed to the high-dose level displayed a moderate-to-severe laryngitis/tracheitis. Fifty percent of the rats receiving the intermediate-dose level displayed a minimal-to-mild tracheitis while one-third had a mild laryngitis. Only one rat receiving the low dose displayed tracheitis. Four of six high-dose rats had a minimal-to-severe interstitial pneumonia. Two of the 18 control rats displayed a minimal interstitial pneumonia. A complete description of these pathological findings is presented in appendix D.

3.5.3 Thirteen-week exposure.

Although none of the control rats displayed laryngitis or tracheitis, all of the male rats receiving the high-dosage level of white phosphorus/felt exhibited a moderate laryngitis. Of the female rats receiving the same dosage level (1161 mg/m^3) of white phosphorus/felt, one of two larynges examined displayed a moderate laryngitis; whereas two out of three tracheae displayed mild-to-moderate tracheitis. Three out of six female rats receiving the medium-dosage level of white phosphorus/ felt displayed a moderate tracheitis; whereas three out of five male rats receiving the same level exposure displayed slight-to-moderate tracheitis. None of the low-dosage-level animals displayed laryngitis or tracheitis. A complete description of these pathological findings is presented in appendix E.

3.5.4 Thirteen-week exposure with four-week recovery period.

Significant findings were limited to the respiratory tracts of the rats exposed to the high- and intermediate-dose levels. Lesions were noted in the larynx or trachea of 15 of 16 high-dose rats and 20 of 24 intermediate-dose rats. Pulmonary lesions were noted in 11 of 16 high-dose and 6 of 24 intermediate-dose rats. None of the control or low-dose animals exhibited significant lesions. A complete description of these pathological findings is presented in appendix F.

3.6 Reproduction studies.

To assess the effects of white phosphorus/felt smoke on reproduction processes in rats, three studies were conducted: teratology, dominant lethal mutation, and reproduction in a single generation. Each of these studies was conducted at both the high- and intermediate-exposure levels and in the control (smoke-free) atmosphere.

At the high-dose level of each study, several of the animals died. Five of the 24 high-dose teratology females died before their scheduled necropsy date. Twelve of the 20 males for the single-generation study died prior to their time for mating. Nine of the 20 males for the dominant lethal mutation study died before they could be mated.

3.6.1 Teratology.

Pregnant females were exposed to test and control atmospheres from days 6 to 15 of gestation. There were no major abnormalities found among the control or test fetuses. The pregnancy rates for control, intermediate-dose and high-dose smoke were 100%, 100%, and 90%, respectively. Data on the number and condition of implants, the mean body weights of the fetuses, and the averaged data on implants appear in appendix B, table B-11. Statistical analysis of these data showed no differences between control and treatment groups.

3.6.2 Dominant lethal mutation.

In the dominant lethal mutation study, analysis by the chi-square method showed that, for the first mating, significantly more of the dams mated to intermediate-dose males had one or more resorptions as compared to the dams mated to control males, appendix B, table B-12. This difference was not observed at the high dose, indicating that the difference observed with the intermediate-dose group was probably not attributable to the effects of white phosphorus/felt smoke.

3.6.3 Single-generation reproduction.

The single-generation reproduction study results are more difficult to analyze. Although there were no significant differences in the body weights of the pups at birth, survivability of the exposed pups was significantly lower than that of the control pups, appendix B, table B-13. Exposures continued for the pups and dams through this 21-day period. Weight gain in the surviving exposed pups was less than that of the control pups, appendix B, table B-14. The difficulty arises from the inability to discern whether the deficiency in weight gain was (1) the result of the exposed dams not caring for their pups, (2) a decrease in mammary gland secretion, (3) the inability of the pups to nurse because of irritated and congested tracheas, or (4) exposure effects.

3.7 Physiological studies.

Physiological measurements were made on days 3 and 4 after the animals were removed from the exposure. The number of animals (sample size) used in the tests are shown in appendix B, tables B-15 and B-16.

An analysis of variance (ANOVA) was made on the data to determine the effect of dose (exposure level), sex difference, and the effect of dose within sexes. Following this, a T-test was performed to locate any significant differences.

The logic for determining a physiological effect from the white phosphorus/felt smoke required that the following conditions apply: (1) a significant difference at a $P \leq 0.05$ level be evidenced by the analysis of variance and Student T test, (2) the differences must be dose related and directional so that significant differences occurring in a low-dose group that were not reinforced by similar effects in the high-dose groups would be considered a chance occurrence, and (3) the difference should be time related unless an adaptive response for increased tolerance has developed. With a bioaccumulated material, it would be expected that effects shown after a 6-week exposure would be repeated after a 13-week exposure. With white phosphorus smoke, it is interesting to note from pathology (page 10) that upper airway irritation, i.e., tracheitis and laryngitis,

decreased after a 6-weeks' exposure. Assuming that phosphorous pentoxide unites with water lining the respiratory tract to form a phosphoric acid, the response to this irritant may be decreasing with time of exposure and consequently the application of present statistical judgments takes the possibility of increased tolerance into effect.

The results are shown in appendix B, tables B-15 through B-17. At both 6- and 13-weeks' exposure, significant sex differences were shown which appear to be related to the greater size of the male rats. These included breathing volumes and the increased inhaled volume responses to 6% CO_2. In addition, blood pressures from male rats were slightly higher than those of female rats. This has been observed in other tests.

Some differences appeared to be the effect of dose and these are indicated in tables B-15 and B-16. However, none of these effects satisfied the logic described above for determining a physiological effect. The same applies for the sex-related doses. It is noted that the sample size in the high-dose exposures was reduced because of deaths during the procedure. It is possible that, if the sample size were larger for high-dose groups, a statistical significance would have been noted. It appears that some effect was developing in the group toward a reduction in tidal volume and an increase in breathing frequency with dose in the 13-week exposed animals. There is also indication that there was less growth in the male rats of this group.

Table B-17 contains the qualitative or nonparametric observations made on rats in the exposure groups. Three of the 13-week high-exposure groups had loud bubbly rales 3 days after exposure which were absent on the fifth post-exposure day.

Although no statistical validation for a functional effect exists, the presence of rales and the tendency for a reduction in tidal volume and an increase in breathing frequency in the high-dose animals indicate that a careful examination of the lung pathology data and the pulmonary resistance data be made.

The evaluation of the pulmonary function as a result of exposure to white phosphorus/felt smoke was carried out on rats that had been exposed for a period of 13 weeks. The method for estimating the pulmonary resistance in these animals was based on a comparison of the plethysmographic pressure during a respiratory cycle and the peak respiratory flow. The rationale for using this method is based on the principle that the changes in pressure in a body plethysmograph during a respiratory cycle are proportional to the alveolar pressure during post cycle. (Pulmonary resistance is determined by the ratio of alveolar pressure to the flow rate during a respiratory cycle; therefore, an estimate of the resistance can be determined by substituting the plethysmographic pressure for the alveolar pressure.)

The results of the pulmonary tests in the unanesthetized rat following 13-weeks exposure to white phosphorus/felt smoke are presented in appendix B, table B-18. There were no significant differences from control values in the respiratory rate or peak inspiratory flow rates in either males or females exposed to smoke. There was no significant difference in the estimated pulmonary resistance of the female rats following exposure. The estimated pulmonary resistance of exposed male rats had a tendency to increase slightly over that of the controls. This increase was significantly different in the low-dose rats but not in the high-dose animals; however, the indication is that some pulmonary damage may be present in the male rats exposed to white phosphorus/felt smoke. No rats were tested at 6 weeks postexposure.

3.8 Behavioral studies.

The behavioral responses of rats exposed to white phosphorus smoke for 6 or 13 weeks was measured using spontaneous activity and passive avoidance tests. In all instances, values are compared statistically to a group of unexposed control rats of equal age and weight.

3.8.1 Spontaneous activity.

The results of these tests are presented in appendix B, table B-19, which shows the gross and fine activity of the rats and the ratio between these two types of activity. Both male and female animals exposed for 6 weeks appeared to exhibit a difference in activity; however, the mean values presented were influenced by one or two animals from each group including controls. If the ratio is calculated from these means, the values become more uniform, indicating that spontaneous activity was not altered as a result of exposure.

3.8.2 Passive avoidance.

Passive avoidance test results are presented in appendix B, table B-20. The exposed female rats, at 1161- and 589-mg/m^3 dose levels and 6-week/13-week exposure time periods, were no different from control animals. This indicated that the animals' ability to passively avoid shocks was not adversely affected by exposure to white phosphorus smoke.[1] Male rats exposed to the high dose received more shocks than the control rats but statistically the values were not significantly different. The number of passive avoidance responses were no different. One of the 13-week high-dose male rats received an unusually large number of shocks with no attempted avoidance, raising the mean value for this group of animals. This animal had either a higher pain threshold than the other animals or a delay in determining how to avoid the shock. The lower-dose male rats showed no differences from the control animals.

4. DISCUSSION

When white phosphorus burns, it forms a number of oxides of phosphorus which are rapidly converted by moisture to phosphorus and phosphonic acids.[1,3] Although at ordinary expected field concentrations (100-200 mg/m^3), this may not be hazardous, some irritation to the eyes, nose, and throat may occur.[4] Cullumbine[5] exposed a total of 108 men to white phosphorus smoke at concentrations from 87 to 1770 mg/m^3. Throat irritation was produced at all concentrations. From these data, it has been estimated that the minimum harassing concentration (requiring a respirator) is about 700 mg/m^3. In the documentation for threshold limit values (TLV), it has been reported that concentrations of 100 mg/m^3 were unendurable except to hardened workers.[6] A TLV of 1 mg/m^3 was established as the level to which nearly all workers may be repeatedly exposed without adverse effect. A man exposed to 100 mg/m^3 would probably mask or remove himself from the smoke cloud.[7]

In the study just completed, the 1000 mg/m^3 dose, with 40% spontaneous deaths and injury to all other animals, was obviously a hazardous concentration. None of the animals exposed at the 500- or 200-mg/m^3 dose levels died. The intermediate dose did, however, produce tracheitis in 50% of the rats. Only one of the low-dose animals showed any signs of irritation.

5. CONCLUSIONS

It would appear that the chance of injury is high at 1161 mg/m^3 and low at 193 mg/m^3. At 589 mg/m^3, one-half of the rats showed some exposure effects.

The rats apparently developed a tolerance to repeated exposures, particularly at the lowest exposure level.

LITERATURE CITED

1. Milham, M. E., Anderson, D. H., Frickel, R. H., and Tarnove, T. L. ARCSL-TR 77067. New Findings on the Nature of WP/RP Smokes. July 1977.

2. Cummings, E. G., Armstrong, R., Farrand, R. L., and McNamara, B. P. ARCSL-TR-79015. Physiological and Behavioral Methodology for Evaluating Chemical Effects on Unanesthetized Rats. March 1979.

3. Van Wazer, J. R. Phosphorus and Its Compounds. Volume 1: Chemistry. pp. 267-279. Interscience Publishers, Inc., New York, New York. 1958.

4. Technical Manual TM 8-285. Treatment of Chemical Agent Casualties. p. 79. Department of the Army, the Navy, and the Air Force. January 1968.

5. Cullumbine, H. Porton Report 2604. The Burning Power and Harassing Effects of White Phosphorus. March 17, 1944.

6. Documentation of the Threshold Limit Values for Substances in Workroom Air. American Conference of Governmental Industrial Hygienists. 3rd edition. 1971.

7. Weimer, J. T., Affleck, G., Preston, J., Lucey, J., Manthei, J., and Lee, F. ARCSL-TR-77052. The Acute Effects of Single Exposures to United Kingdom Red Phosphorus Screening Smoke in Rats, Guinea Pigs, Rabbits, and Dogs. August 1977.

APPENDIX A

CHEMICAL ANALYSIS OF WHITE PHOSPHORUS SMOKE*

Exposure chamber air samples received were diluted with distilled water, shaken, then boiled 10 minutes to convert the phosphorus acids to orthophosphoric acid, then cooled to room temperature. Sample volume was measured after boiling. Using a pH meter as an indicator, the acid content was determined by titration against 0.10043 N sodium hydroxide to a pH of 9.6. After measuring the amount of 0.10043 N sodium hydroxide required to adjust the sample pH to 9.6, the following formula was used to determine normality of the orthophosphoric acid:

1. $N_{sample} \times V_{sample} = N_{NaOH} \times V_{NaOH}$

   N = Normality

   V = Volume of sample in milliliters

The normality of the acid is multiplied by 32.66 (milligrams per milligram-equivalents of orthophosphoric acid).

2. $$\frac{\text{milligram equivalents}}{\text{milliliters}} \times \frac{32.66 \text{ milligrams}}{\text{milligram equivalents}} = \frac{\text{milligrams}}{\text{milliliters of orthophosphoric acid}}$$

   (normality of sample)

3. $$\frac{\text{milligrams}}{\text{milliliters}} \times \text{milliliters} = \text{milligrams of orthophosphoric acid in sample}$$

* B. P. Pearce. Porton Technical Paper 154. The Stability of Red Phosphorus Compositions. June 1974. UNCLASSIFIED Paper.

APPENDIX B

DETAILS OF TOXICOLOGICAL EVALUATION

Table B-1. Inhalation Exposure Doses Produced by Burning Cubes of White Phosphorus/Felt

Cube weight	Average exposure concentration	Average daily 15-minute exposure Ct	Total cumulative exposure Ct
gm	mg/m^3	mg min/m^3	mg min/m^3
20	1161	17,415	1,097,151 (63 days)
10	589	8,833	556,480 (63 days)
3	192.5	2,887	178,991 (62 days)

Table B-2. Spontaneous Deaths in Rats Exposed to the High-Dose Concentration of White Phosphorus Smoke

Exposure day	Deaths		Cumulative exposure Ct
	Male	Female	
			mg min/m^3
4		1	54,225
5	1		69,225
9	1		143,975
10	1		158,820
11		2	176,340
12	1	3	194,790
13	1	1	210,960
14	2	1	225,120
16		1	251,925
23	2		376,260
24		1	397,650
25	1		420,330
26	1		441,300
27	1		460,545
29		1	499,560
34	1		588,045
47	1		813,021
54	1		936,820
57	1		995,426

Table B-3. Organ and Total Body Weights in Male Sprague-Dawley Rats After Repeated Exposures to White Phosphorus Smoke

Dose level	Exposure time	Number of animals	Total body		Heart		Lungs		Liver		Kidneys		Gonads	
			Mean	Standard error	Mean	Standard error	Mean	Standard error	Mean	Standard error	Mean	Standard error	Mean	Standard error
	weeks		grams											
High	6	0	—	—	—	—	—	—	—	—	—	—	—	—
	13	6	373	19	1.62	0.23	3.32+	0.22	14.9	1.8	2.78++	0.16	3.47	0.11
	17+++	9	455	30	1.77	0.20	3.55	0.35	17.2	3.4	3.12	0.45	3.40	0.60
High control	6	3	382	26	1.50	0.14	3.60	0.14	18.2	1.4	2.93	0.47	3.67	0.41
	13	3	389	14	1.53	0.17	2.93	0.12	15.2	2.9	3.00	0.82	3.67	0.19
	17+++	6	417	46	1.57	0.14	3.32	0.42	16.0	2.3	2.93	0.44	3.37	0.14
Intermediate	6	6	374	20	1.47	0.24	3.32	0.56	16.3	1.2	2.67	0.28	3.47	0.26
	13	6	433	27	1.68	0.19	3.25	0.22	16.2	2.6	2.83	0.31	3.52	0.21
	17+++	12	461++	46	1.64	0.21	3.36	0.37	17.9	3.1	3.11	0.31	3.62	0.47
Intermediate control	6	3	368	15	1.37	0.09	3.07	0.09	15.4	0.8	2.93	0.26	3.27	0.20
	13	3	456	34	1.63	0.17	3.27	0.17	16.0	1.2	2.87	0.05	3.30	0.33
	17+++	6	509	32	1.77	0.12	4.23	0.82	19.5	3.6	3.52	0.36	3.02	1.36
Low	6	6	346	20	1.50	0.15	3.50	0.36	16.2	1.5	2.67	0.11	3.35	0.10
	13	6	422	18	1.43	0.20	3.30	0.36	15.9	1.5	2.75	0.21	3.45	0.18
	17+++	6	453	55	1.48	0.23	2.98++	0.38	17.8	2.5	2.78	0.35	3.48	0.37
Low control	6	3	338	53	1.43	0.17	3.35	0.15	15.3	3.4	2.73	0.33	3.13	0.40
	13	3	444	63	1.53	0.19	3.43	0.25	18.8	2.8	3.00	0.29	3.63	0.25
	17+++	3	484	11	1.90	0.24	3.43	0.12	18.5	3.0	3.30	0.24	3.57	0.17

\+ - Significantly higher than control based on statistical "t" test.
++ - Significantly lower than control based on statistical "t" test.
+++ - Four weeks' postexposure.

Table B-4. Organ and Total Body Weights in Female Sprague-Dawley Rats After Repeated Exposures to White Phosphorus Smoke

Dose level	Exposure time	Number of animals	Total body		Heart		Lungs		Liver		Kidneys		Gonads	
			Mean	Standard error	Mean	Standard error	Mean	Standard error	Mean	Standard error	Mean	Standard error	Mean	Standard error
	weeks		grams											
High	6	6	241	12	0.93	0.09	2.63+	0.38	9.0	0.6	1.65	0.13	0.200	0.082
	13	6	241	19	1.15	0.10	2.67	0.41	9.4	1.9	1.82	0.31	0.183	0.037
	17	7	255	16	1.06	0.14	2.76	0.57	10.1	0.7	1.79	0.16	0.143	0.050
High control	6	3	235	9	0.97	0.05	2.10	0.08	10.0	0.5	1.70	0.08	0.167	0.047
	13	3	270	12	1.10	0.14	2.43	0.19	9.4	1.2	1.87	0.12	0.200	-
	17	6	254	19	1.07	0.09	2.32	0.28	10.0	1.8	1.75	0.24	0.167	0.047
Intermediate	6	6	247	22	0.97	0.09	2.47	0.24	9.7	1.2	1.85	0.30	0.183	0.037
	13	6	269	21	1.20	0.13	2.75	0.25	10.3	1.1	1.90	0.21	0.200	0.037
	17	12	266	24	0.99++	0.10	2.41	0.18	9.4++	1.2	1.89++	0.18	0.150	0.050
Intermediate control	6	3	246	6	1.03	0.04	2.43	0.09	10.0	0.4	1.70	0.08	0.167	0.04
	13	3	260	28	1.17	0.12	2.50	0.08	9.9	0.6	1.83	0.09	0.200	-
	17	6	275	13	1.15	0.08	2.33	0.12	10.8	1.1	2.15	0.19	0.150	0.05
Low	6	6	232	16	1.08	0.11	2.48	0.23	9.8	1.2	1.90	0.20	0.167	0.047
	13	6	240	15	1.05	0.13	2.33	0.09	8.8	0.9	1.83	0.17	0.167	0.047
	17	6	287	23	1.08	0.11	2.45	0.13	10.7	1.4	1.98	0.15	0.183+	0.037
Low control	6	3	229	24	1.07	0.17	2.47	0.45	8.9	1.4	1.90	0.16	0.200	0.08
	13	3	243	20	1.07	0.05	2.37	0.05	9.3	0.8	1.93	0.20	0.233	0.05
	17	2	270	5	1.25	0.05	2.35	0.15	9.9	-	2.65	0.35	0.100	-

\+ - Significantly higher than control based on statistical "t" test.
++ - Significantly lower than control based on statistical "t" test.

Table B-5. Hematology in Rats Exposed for Six Weeks to White Phosphorus Smoke

Cumulative exposure Ct	Red blood cells			White blood cells			Hematocrit			Hemoglobin			Neutrophils		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m^3		x 10^6/mm^3	x 10^6/mm^3		per mm^3	per mm^3		%	%		mg/100 ml	mg/100 ml		%	%
499,560	6	6.32	0.77	6	8333.33	1129.40	6	35.70	4.46	6	13.53	1.59	-	-	-
Control	6	6.90	0.58	6	9650.00	1698.77	6	38.53	2.95	6	15.10	0.87	-	-	-
246,285	12	7.02	0.53	12	6633.33	1818.12	12	39.11	3.34	12	14.42	0.94	12	7.42	5.63
Control	6	6.90	0.34	6	5966.67	1188.37	6	38.10	2.19	6	14.18	0.84	6	7.00	4.16
84,019	12	6.50	0.54	12	8325.00	1799.13	12	35.68*	3.08	12	13.51*	0.94	12	8.92	5.25
Control	6	6.95	0.41	6	10233.33	1569.15	6	38.58	2.10	6	14.68	0.71	6	10.17	3.80

Cumulative exposure Ct	Band cells			Lymphocytes			Monocytes			Eosinophils			Basophils		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m^3		%	%		%	%		%	%		%	%		%	%
499,560	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Control	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
246,285	-	-	-	12	91.50	5.06	-	-	-	6	2.17	1.67	-	-	-
Control	-	-	-	6	92.67	4.57	1	1.00	0.00	1	1.00	0.00	-	-	-
84,019	-	-	-	12	90.25	5.55	1	1.00	0.00	6	1.50	0.76	-	-	-
Control	1	1.00	0.00	6	88.00	4.93	3	2.00	0.82	2	2.00	1.00	-	-	-

* Significantly lower than control based on statistical "t" test.

NOTE: Statistical evaluation of differential-white count components, monocytes, eosinophils, basophils and band cells may be meaningless since normal occurrences range from 1% to 10 %.

Table B-6. Hematology in Rats Exposed for Thirteen Weeks to White Phosphorus Smoke

Cumulative exposure Ct	Red blood cells			White blood cells			Hematocrit			Hemoglobin			Neutrophils		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m^3		x 10^6/mm^3	x 10^6/mm^3		per mm^3	per mm^3		%	%		mg/100 ml	mg/100 ml		%	%
1,097,151	12	7.32$^+$	0.59	12	15,125.00	6301.47	12	40.12$^+$	3.40	12	15.43$^+$	1.28	10	31.10^{++}	12.04
Control	6	8.12	0.46	6	14,350.00	3114.35	6	44.83	1.64	6	17.48	0.77	6	15.00	6.53
556,480	12	7.13	0.41	12	7691.67$^+$	607.53	12	39.05	2.26	12	14.77	0.77	12	15.67	12.47
Control	6	7.38	0.68	6	8633.33	727.25	6	39.47	3.16	6	15.10	1.23	4	11.00	8.77
178,991	12	7.04^{++}	0.88	12	9533.33	2489.76	12	38.51$^+$	4.63	12	13.95^{++}	1.90	12	14.58	4.61
Control	6	5.46	1.05	6	8416.67	2625.15	6	29.88	6.50	6	10.98	2.00	6	10.67	4.85

Cumulative exposure Ct	Band cells			Lymphocytes			Monocytes			Eosinophils			Basophils		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m^3		%	%		%	%		%	%		%	%		%	%
1,097,151	-	-	-	10	66.70	13.10	1	1.00	0.00	6	3.50	1.38	-	-	-
Control	-	-	-	6	84.33	7.23	-	-	-	2	2.00	1.00	-	-	-
556,480	-	-	-	12	83.67	12.39	-	-	-	3	2.67	0.94	-	-	-
Control	-	-	-	4	88.50	8.99	-	-	-	1	2.00	0.00	-	-	-
178,991	-	-	-	12	84.67	4.48	3	1.33	0.47	4	1.25	0.43	-	-	-
Control	-	-	-	6	88.83	4.78	-	-	-	2	1.50	0.50	-	-	-

Table B-7. Hematology in Rats 30 Days After 13 Weeks' Exposure to White Phosphorus Smoke

Cumulative exposure Ct	Red blood cells			White blood cells			Hematocrit			Hemoglobin			Neutrophils		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m^3		x 10^6/mm^3	x 10^6/mm^3		per mm^3	per mm^3		%	%		mg/100 ml	mg/100 ml		%	%
1,097,151	16	7.15	1.0	16	11,506.25+	1747.31	16	40.81	4.55	16	14.48	1.07	16	33.44+	16.56
control	12	7.29	0.71	12	9558.33	2457.80	12	39.31	4.44	12	14.45	1.84	12	20.08	11.16
556,480	24	7.07	0.57	24	8854.17	1918.55	24	38.57++	3.00	24	14.44	0.99	24	11.17	6.38
control	12	7.47	0.43	12	9575.00	2876.09	12	44.06	2.39	12	15.02	0.92	12	13.92	5.12
178,991	12	6.67	0.93	12	10,959.33	1141.97	12	37.74	4.94	12	14.96	1.86	12	12.42	5.33
control	5	6.61	0.70	5	11,600.00	1404.28	5	36.96	3.91	5	14.74	1.22	5	12.00	6.60

Cumulative exposure Ct	Band cells			Lymphocytes			Monocytes			Eosinophils			Basophils		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m^3		%	%		%	%		%	%		%	%		%	%
	-	-	-	16	65.75	16.74	2	1.00	0.00	4	2.75	0.83	-	-	-
	1	1.00	0.00	12	78.67	11.01	3	1.00	0.00	7	1.57	0.73	-	-	-
	-	-	-	24	88.04	6.26	1	4.00	0.00	13	1.15	0.36	-	-	-
	-	-	-	12	85.58	5.19	-	-	-	5	1.20	0.40	-	-	-
	-	-	-	12	87.00	4.93	-	-	-	4	1.75	0.83	-	-	-
	-	-	-	5	87.20	6.52	-	-	-	3	1.33	0.47	-	-	-

+ Significantly higher that control based on statistical "t" test.
++ Significantly lower than control based on statistical "t" test.

NOTE: Statistical evaluation of differential-white count components, monocytes, eosinophils, basophils, and band cells may be meaningless since normal occurrences range from 1% to 10%.

Table B-8. Blood Chemistry in Rats Bled After 6 Weeks' Exposure to White Phosphorus Smoke

Cumulative exposure Ct	Glucose			Blood urea nitrogen			Creatinine			Sodium			Potassium		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m^3		mg/dl	mg/dl		mg/dl	mg/dl		mg/dl	mg/dl		mg/dl	mg/dl		mg/dl	mg/dl
499,560	6	150.17+	12.40	6	23.00	3.06	6	0.70	0.08	6	145.17	1.77	6	4.43	0.55
Control	6	187.17	30.10	6	22.83	2.97	6	0.63	0.09	6	145.50	2.36	6	4.97	1.02
246,285	12	165.83	15.46	12	21.33	1.84	12	0.54	0.12	12	146.58	1.38	12	4.52	0.51
Control	6	171.67	19.88	6	23.83	2.97	6	0.65	0.17	6	147.33	3.25	6	4.47	0.61
84,019	11	181.18++	22.39	11	20.64	2.38	11	0.55	0.08	11	145.27	2.18	11	4.26	0.86
Control	6	159.17	8.03	6	19.33	0.75	6	0.50	0.10	6	145.83	1.21	6	4.05	0.35

Cumulative exposure Ct	Chloride			Carbon dioxide			Uric acid			Total protein			Albumin		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m^3		meq/l	meq/l		meq/l	meq/l		mg/dl	mg/dl		mg/dl	mg/dl		mg/dl	mg/dl
499,560	6	103.33	1.11	6	21.67	4.31	6	0.85	0.68	6	5.58	0.42	6	3.03	0.32
Control	6	101.67	1.37	6	22.00	3.83	6	1.37	1.09	6	6.07	0.23	6	3.30	0.15
246,285	12	102.92	2.36	12	22.33	2.39	12	1.32	0.78	12	6.17	0.22	12	3.23	0.12
Control	6	102.67	2.13	6	23.50	4.19	6	1.48	0.84	6	6.05	0.26	6	3.18	0.15
84,019	11	103.55	2.23	11	19.09	5.81	11	1.47	1.37	11	5.54	0.53	11	2.96	0.46
Control	6	104.00	2.00	6	22.00	4.62	6	0.73	0.26	6	5.87	0.43	6	3.15	0.24

Cumulative exposure Ct	Globulin			Calcium			Phosphate			Cholesterol			Triglycerides		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m^3		gm/dl	gm/dl		gm/dl	gm/dl		mg/dl	mg/dl		mg/dl	mg/dl		mg/dl	mg/dl
499,560	6	2.55	0.28	6	9.77	0.57	6	4.93+	0.65	6	75.00	6.11	6	33.67+	16.60
Control	6	2.77	0.14	6	10.25	0.43	6	6.07	0.51	6	78.50	11.77	6	69.83	23.02
246,285	12	2.93	0.16	12	9.79	0.36	12	5.93	0.54	12	73.17+	5.98	12	53.58	39.28
Control	6	2.87	0.14	6	9.65	0.27	6	5.90	0.75	6	79.67	4.31	6	89.00	46.63
84,019	11	2.57	0.18	11	9.67	0.33	11	5.95	1.13	11	106.18	23.92	11	49.91	32.24
Control	6	2.72	0.27	6	9.87	0.25	6	6.15	0.52	6	97.67	9.84	6	51.83	24.13

Cumulative exposure Ct	Alkaline phosphatase			Glutamic oxalacetic transaminase			Glutamic pyruvic transaminase			Lactic dehydrogenase			Total bilirubin		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m^3		μl	μl		μl	μl		μl	μl		μl	μl		mg/dl	mg/dl
	6	230.50	51.19	6	147.33	90.76	6	57.33	14.01	6	382.17	297.98	6	0.10	0.00
	6	335.83	99.78	6	119.83	25.47	6	60.67	9.50	6	322.67	88.68	6	0.10	0.00
	12	366.17	139.84	12	120.83	54.22	12	53.08	16.65	12	287.50	173.36	12	0.32	0.39
	6	301.00	96.19	6	140.00	81.76	6	59.17	21.99	6	1472.17	2696.11	6	0.10	0.00
	11	355.09	90.90	11	126.18	44.03	11	55.09	10.72	11	342.27	173.08	11	0.10	0.00
	6	306.00	105.04	6	117.50	33.59	6	49.90	9.45	6	265.67	43.60	6	0.10	0.00

+ Significantly lower than control based on statistical "t" test.
++ Significantly lower than control based on statistical "t" test.

Table B-9. Blood Chemistry in Rats Bled After 13 Weeks Exposure to White Phosphorus Smoke

Cumulative exposure Ct	Glucose			Blood urea nitrogen			Creatinine			Sodium			Potassium		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m^3		mg/dl	mg/dl		mg/dl	mg/dl		mg/dl	mg/dl		meq/l	meq/l		meq/l	meq/l
499,560	12	178.58	22.76	12	20.58	4.33	12	0.57	0.07	12	146.61	2.05	12	4.43	0.65
Control	6	168.83	17.35	6	17.50	1.71	6	0.53	0.05	6	147.17	0.69	6	4.28	0.38
246,285	12	166.50	12.27	12	20.33	3.09	12	0.57	0.11	12	144.33	1.60	12	4.07	0.22
Control	6	174.50	14.85	6	21.33	3.14	6	0.63	0.5	6	144.50	0.96	6	4.20	0.68
84,019	12	171.00+	16.87	12	21.67	1.49	12	0.52	0.09	12	145.92	0.86	12	4.18	0.43
Control	6	187.17	7.45	6	23.00	2.58	6	0.57	0.05	6	145.50	0.96	6	4.27	0.36

Cumulative exposure Ct	Chloride			Carbon dioxide			Uric acid			Total protein			Albumin		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m^3		meq/l	meq/l		meq/l	meq/l		mg/dl	mg/dl		gm/dl	gm/dl		gm/dl	gm/dl
	12	106.00	2.68	12	17.58	4.31	12	1.33	1.38	12	5.85	0.27	12	3.30	0.22
	6	107.50	0.50	6	17.50	1.71	6	1.05	0.81	6	5.75	0.32	6	3.30	0.14
	12	104.92	2.20	12	19.83	3.13	12	1.23	0.40	12	5.78	0.20	12	3.18	0.11
	6	104.67	3.45	6	21.17	3.18	6	1.18	0.64	6	5.90	0.19	6	3.33	0.09
	12	103.58	1.85	12	19.42	2.90	12	0.86	1.13	12	5.80	0.20	12	3.19	0.13
	6	104.33	1.97	6	19.00	2.89	6	1.08	0.41	6	5.83	0.25	6	3.10	0.16

Cumulative exposure Ct	Globulin			Calcium			Phosphate			Cholesterol			Triglycerides		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m^3		gm/dl	gm/dl		gm/dl	gm/dl		mg/dl	mg/dl		mg/dl	mg/dl		mg/dl	mg/dl
	12	2.55	0.13	12	9.68	0.57	12	4.92	1.09	12	111.42	30.22	12	36.25	24.69
	6	2.45	0.24	6	9.70	0.24	6	5.08	0.75	6	123.83	12.35	6	57.67	21.01
	12	2.60	0.15	12	9.37	0.23	12	4.70	0.45	12	74.25	9.69	12	31.33	33.24
	6	2.57	0.11	6	9.55	0.29	6	5.07	0.53	6	74.33	11.01	6	21.50	20.95
	12	2.61	0.13	12	9.67	0.20	12	5.01	0.52	12	77.92	8.62	12	37.42	24.68
	6	2.73	0.19	6	9.43	0.30	6	5.02	0.49	6	77.33	6.05	6	20.67	18.12

Cumulative exposure Ct	Alkaline phosphatase			Glutamic oxalacetic transaminase			Glutamic pyruvic transaminase			Lactic dehydrogenase			Total bilirubin		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m^3		µl	µl		µl	µl		µl	µl		µl	µl		mg/dl	mg/dl
	12	352.58++	103.00	12	109.08	37.23	12	55.17	13.40	12	299.00	168.56	12	0.10	0.00
	6	270.50	48.41	6	85.33	16.36	6	47.17	7.06	6	258.83	85.31	6	0.10	0.00
	12	262.00	72.63	12	91.67	38.87	12	45.75	10.30	12	290.50	117.40	12	0.16	0.05
	6	247.67	49.52	6	80.33	9.29	6	40.17	6.12	6	221.33	64.50	6	0.15	0.05
	12	287.42	101.75	12	108.50	30.82	12	56.92	20.54	12	253.67	49.95	12	0.11	0.03
	6	295.50	86.50	6	133.67	53.31	6	62.50	15.02	6	411.00	283.72	6	0.12	0.04

* Significantly lower than control based on statistical "t" test.
** Significantly higher than control based on statistical "t" test.

Table B-10. Blood Chemistry in Rats Bled 4 Weeks After a 13-week Exposure to White Phosphorus Smoke

Cumulative exposure Ct	Glucose			Blood urea nitrogen			Creatinine			Sodium			Potassium		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m^3		mg/dl	mg/dl		mg/dl	mg/dl		mg/dl	mg/dl		meq/l	meq/l		meq/l	meq/l
499,560	16	173.81	12.53	16	22.25	2.22	16	0.72	0.09	16	147.19•	1.78	16	4.13	0.28
Control	12	175.17	20.32	12	22.67	3.77	12	0.69	0.08	12	145.92	1.04	12	4.08	0.26
246,285	24	180.21	27.87	24	20.04•	1.84	24	0.57	0.07	24	146.42	3.45	24	4.17	0.66
Control	12	168.08	15.26	12	21.58	1.32	12	0.59	0.13	12	147.50	1.55	12	4.05	0.26
84,019	12	196.75	26.54	12	20.33	1.31	12	0.53	0.06	12	145.58	1.66	12	4.51	0.67
Control	5	189.80	20.71	5	18.80	1.17	5	0.56	0.12	5	144.60	1.62	5	4.66	0.69

Cumulative exposure Ct	Chloride			Carbon dioxide			Uric acid			Total protein			Albumin		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m^3		meq/l	meq/l		meq/l	meq/l		mg/dl	mg/dl		gm/dl	gm/dl		gm/dl	gm/dl
	16	105.56	1.37	16	19.31	2.52	16	0.98	0.39	16	5.86	0.25	16	3.27	0.18
	12	105.83	2.37	12	21.17	2.82	12	1.02	0.70	12	5.92	0.33	12	3.32	0.27
	24	103.42	2.18	24	20.92	2.71	24	1.01	0.67	24	5.64••	0.29	24	3.17••	0.17
	12	104.00	2.61	12	20.00	3.46	12	0.76	0.25	12	6.07	0.29	12	3.39	0.22
	12	103.25	1.69	12	25.08	2.25	12	1.35	1.10	12	6.06	0.35	12	3.38	0.12
	5	103.40	0.49	5	24.80	0.75	5	1.16	0.83	5	5.88	0.43	5	3.28	0.24

Cumulative exposure Ct	Globulin			Calcium			Phosphate			Cholesterol			Triglycerides		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m^3		gm/dl	gm/dl		gm/dl	gm/dl		mg/dl	mg/dl		mg/dl	mg/dl		mg/dl	mg/dl
	16	2.58	0.19	16	9.61	0.27	16	4.69	0.63	16	79.37	18.26	16	49.62	34.81
	12	2.59	0.11	12	9.42	0.49	12	4.32	0.81	12	78.33	19.72	12	54.00	34.45
	24	2.47••	0.20	24	9.56	0.54	24	5.17	0.59	24	74.83••	8.54	24	65.92	52.12
	12	2.67	0.12	12	9.75	0.42	12	5.01	0.67	12	84.75	13.55	12	94.83	65.87
	12	2.67	0.19	12	10.10	0.24	12	5.33	0.56	12	74.25	9.44	12	59.73	32.14
	5	2.60	0.28	5	9.98	0.55	5	5.36	0.33	5	75.60	9.41	5	48.80	16.44

Cumulative exposure Ct	Alkaline phosphatase			Glutamic oxalacetic transaminase			Glutamic pyruvic transaminase			Lactic dehydrogenase			Total bilirubin		
	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation	No. of animals	Mean	Standard deviation
mg min/m^3		μl	μl		μl	μl		μl	μl		μl	μl		mg/dl	mg/dl
	16	274.69	69.42	16	91.62	26.71	16	48.62	13.72	16	278.06	113.32	16	0.10	0.00
	12	299.83	102.99	12	97.83	21.56	12	56.25	11.36	12	305.67	76.71	12	0.10	0.00
	24	262.33	75.80	24	107.92	41.29	24	57.08	25.54	24	323.08	109.66	24	0.10	0.00
	12	304.92	88.19	12	110.92	38.15	12	69.50	21.80	12	335.92	61.94	12	0.10	0.00
	12	293.75	90.84	12	126.08	90.45	12	80.00	57.57	12	246.92	89.23	12	0.25	0.14
	5	218.00	60.98	5	93.40	17.45	5	58.40	11.57	5	255.80	85.11	5	0.10	0.00

• Significantly lower than control based on statistical "t" test.
•• Significantly higher than control based on statistical "t" test.

Table B-11. Teratologic Effects on Pups of Female Rats Futhanatized on Dav 20 After Inhalation of White Phosphorus/Felt Smoke During Organogenesis

	Dose level		
	Air controls	589 mg/m^3	1,161 mg/m^3
Number pregnant	20	20	18
Percent pregnant	100	100	90
Total implants	238	242	221
Live implants	225	236	206
Dead implants	13	6	15
Percent dead implants	5.46	2.48	6.79
Mean weight in grams			
Male	3.91 ± 0.32	3.83 ± 0.36	3.87 ± 0.38
Female	3.76 ± 0.34	3.67 ± 0.30	3.66 ± 0.40
Mean body weight - all pups	3.84 ± 0.33	3.76 ± 0.34	3.77 ± 0.40
Average implants per pregnant female	11.90 ± 1.45	12.10 ± 1.37	12.28 ± 1.96
Average live implants per pregnant female	11.25 ± 1.41	11.80 ± 1.61	11.44 ± 2.28
Average dead implants per pregnant female	0.65 ± 0.67	0.30 ± 0.57	0.83 ± 1.10

Table B-12. Reproductive Data for Female Rats Mated to Males Exposed to White Phosphorus/Smoke
(Numbers in parentheses indicate the number of animals in each category.)

Group	Week	Number mated	Number pregnant	M.I.*	C.L.I.	I.I.	P.I.L.I.	F.I.	R.I.	N.V.F./V.F.	N.V.F.≥1	N.V.F.≥2
Air control	1	20	14	70	(183) 13.07	(165) 11.79	(18) 1.29	(158) 11.29	(7) 0.50	7/158	5/9	2/12
	2	20	19	95	(253) 13.32	(238) 12.53	(15) 0.79	(223) 11.74	(15) 0.79	15/223	9/10	4/15
589 mg/m^3	1	20	19	95	(257) 13.53	(224) 11.79	(33) 1.74	(210) 11.05	(14) 0.74*	14/210	13/6	1/18
	2	20	20	100	(278) 13.90	(259) 12.95	(19) 0.95	(249) 12.45	(10) 0.50	10/249	7/13	3/17
1161 mg/m^3	1	20	18	90	(256) 14.22	(226) 12.56	(30) 1.67	(215) 11.94	(11) 0.61	11/215	8/10	2/16
	2	20	18	90	(255) 14.17	(219) 12.17	(36) 2.00	(215) 11.94	(4) 0.22	4/215	4/14	0/18

*Abbreviations used

M.I. (mating index) = $\frac{\text{total number of females pregnant}}{\text{total number of females mated}} \times 100$

C.L.I. (corpora lutea index) = $\frac{\text{total number of corpora lutea}}{\text{total number of pregnant females}}$

I.I. (implantation index) = $\frac{\text{total number of implantation sites}}{\text{total number of pregnant females}}$

P.I.L.I. (pre-implantation loss index) = $\frac{\text{total number of corpora lutea-total number of implantation sites}}{\text{total number of pregnant females}}$

F.I. (fetal index) = $\frac{\text{total number of viable fetuses}}{\text{total number of pregnant females}}$

R.I. (resorption index) = $\frac{\text{total number of deaths (early and late)}}{\text{total number of pregnant females}}$

N.V.F./V.F. = $\frac{\text{total number of nonviable fetuses}}{\text{total number of viable fetuses}}$

N.V.F.≥1 = $\frac{\text{total number of females with one or more nonviable fetuses}}{\text{total number of females with zero nonviable fetuses}}$

N.V.F.≥2 = $\frac{\text{total number of females with two or more nonviable fetuses}}{\text{total number of females with one or zero nonviable fetuses}}$

**Significant at p = 0.05

Table B-13. Viability, Survival, and Lactation Indices in a Single-Generation Study of Reproduction Performance During Exposure to White Phosphorous/Felt Smoke

Index	Generation	Control	Low dose *	High dose **
		%	%	%
Viability index	F1	99.48	93.23	64.12
Survival index: day 21	F1	98.44	92.19	30.23
Lactation index	F1	98.95	98.88	47.15

* Low dose animals exposed to 589 mg/m^3 white phosphorus/felt smoke.
** High dose animals exposed to 1,161 mg/m^3 white phosphorus/felt smoke.

Table B-14. Single-Generation Reproduction Study of White Phosphorus/...lt Smoke

Davs post-natal	Weight change (mean and SD)					
	Males			Females		
	Control	Low dose*	High dose**	Control	Low dose*	High dose**
1	(103) 6.63 ± 0.57	(90) 7.26 ± 0.74	(136) 6.38 ± 0.62	(89) 6.49 ± 0.69	(102) 6.76 ± 0.75	(166) 6.01 ± 0.69
4	(102) 10.41 ± 1.27	(84) 11.30 ± 1.15	(92) 9.41 ± 1.48	(89) 10.39 ± 1.54	(95) 10.71 ± 1.19	(101) 8.99 ± 1.59
7	(102) 15.36 ± 2.18	(84) 16.66 ± 1.67	(84) 13.97 ± 1.86	(89) 15.45 ± 2.69	(95) 15.64 ± 1.75	(90) 13.62 ± 2.26
14	(100) 29.59 ± 4.19	(83) 31.39 ± 3.52	(47) 26.46 ± 5.03	(89) 29.97 ± 5.31	(94) 29.46 ± 2.72	(44) 25.93 ± 5.53
21	(100) 45.05 ± 8.16	(83) 50.62 ± 5.34	(47) 41.10 ± 9.52	(89) 45.16 ± 9.71	(94) 46.55 ± 5.09	(44) 41.50 ±11.15

* Low dose, 589 mg/m^3.
** High dose, 1,161 mg/m^3.

Table B-15. Physiological Effects of White Phosphorous/Felt Smoke on Rats After 6-Weeks' Exposure

Measurement	Units	Exposure									ANOVA			
		Control			Low-dose			Highdose			Significance of F ratio			
		All	Males	Females	All	Males	Females	All	Males	Females	Dose	Male x female	Dose: male	Dose: female
Sample size		12	6	6	12	6	6	7	3	3				
Weight	grams	317 ± 56	365 ± 10	269 ± 25	327 ± 78	396 ± 44	258 ± 12	300 ± 54	347 ± 10	252 ± 25		0.001		0.01
Temperature, rectal	degrees F	100.1 ± 0.4	100.1 ± 0.5	100.4 ± 0.2	100.2 ± 0.7	100.2 ± 0.8	100.0 ± 0.5	100.7 ± 0.7	100.2 ± 0.5	101.1 ± 0.5*				
Tidal volume	ml	1.79 ± .34	1.96 ± .32	1.55 ± .27	1.96 ± .29	2.07 ± .14	1.84 ± .37	1.68 ± .18	1.82 ± .08	1.53 ± .10		0.01		
Minute volume	ml	186 ± 47	207 ± 32	171 ± 47	206 ± 37	228 ± 26	172 ± 31	180 ± 45	215 ± 28	144 ± 19		0.001		
Breathing frequency	breaths per minute	107 ± 17	106 ± 7.1	108 ± 24	103 ± 37	111 ± 14	96 ± 17	106 ± 17	118 ± 11	94 ± 11				
Tidal volume, 5% CO_2	ml	2.91 ± .40	3.07 ± .28	2.75 ± .46	3.15 ± .65	3.67 ± .45	2.63 ± .15	2.90 ± .42	3.26 ± .18	2.55 ± .14		0.001	0.05	
Minute volume, 5% CO_2	ml	469 ± 105	451 ± 92	366 ± 107	463 ± 131	564 ± 59	362 ± 99	418 ± 97	505 ± 27	331 ± 9.0				
Breathing frequency, 5% CO_2	b/min	139 ± 23	146 ± 24	132 ± 21	145 ± 19	153 ± 7.2	136 ± 24	143 ± 17	155 ± 12	130 ± 7.6		0.05		
Blood pressure, systolic	mm Hg	118 ± 5	122 ± 4	116 ± 5	120 ± 12	126 ± 11	114 ± 11	115 ± 10	116 ± 12	113 ± 9		0.05		
Heart rate (from blood pressure)	b/min	413 ± 61	431 ± 69	395 ± 51	378 ± 39	397 ± 33	359 ± 37	377 ± 35	357 ± 26	396 ± 37				
Heart rate (from ECG)	b/min	459 ± 49	469 ± 53	450 ± 48	484 ± 46	516 ± 19*	451 ± 42	397 ± 46*	396 ± 46	399 ± 56	0.01		0.01	
ECG- P-wave amplitude	mv	.067 ± .029	.067 ± .030	.067 ± .031	.064 ± .032	.055 ± .029	.073 ± .035	.085 ± .019	.090 ± .010	.080 ± .027				
P-wave duration	sec	.017 ± .002	.017 ± .002	.017 ± .001	.017 ± .002	.016 ± .001	.017 ± .002	.018 ± .002	.019 ± .002	.017 ± .001				
P-R interval	sec	.046 ± .003	.046 ± .004	.046 ± .002	.046 ± .005	.046 ± .004	.045 ± .006	.046 ± .004	.049 ± .002	.043 ± .001				
Q-R-S interval	sec	.014 ± .002	.014 ± .002	.014 ± .002	.015 ± .002	.015 ± .002	.015 ± .002	.016 ± .002	.016 ± .002	.016 ± .002		0.01		
Q-T interval	sec	.059 ± .009	.053 ± .008	.064 ± .005	.057 ± .007	.054 ± .008	.061 ± .004	.065 ± .005	.062 ± .002	.067 ± .005	0.05		0.05	
R-wave amplitude	mv	.32 ± .15	.35 ± .10	.28 ± .20	.23 ± .13	.20 ± .09	.25 ± .12	.43 ± .07	.47 ± .06	.39 ± .07				
T-wave amplitude	mv	.13 ± .05	.12 ± .04	.15 ± .07	.12 ± .07	.09 ± .07	.14 ± .07	.15 ± .03	.15 ± .04	.15 ± .02				
Treadmill run	min	10.5 ± 3.0	11.8 ± 3.0	9.3 ± 1.3	10.4 ± 5.7	7.7 ± 6.6	13 ± 3.3	11.5 ± 2.5	10.5 ± 1.5	12.6 ± 3.2				

± Values indicate standard deviation.

* Student's "t" test - different from control at P < 0.05.

Table B-16. Physiological Effects of White Phosphorous/Felt Smoke on Rats After 13 Weeks' Exposure

Measurement	Units	Exposure									ANOVA			
		Control			Low-dose			High-dose			Significance of F ratio (A)			
		All	Males	Females	All	Males	Females	All	Males	Females	Dose	Male x female	Dose: male	Dose: female
Sample size		12	6	6	12	6	6	7	4	3				
Weight	grams	365 ± 83	441 ± 16	288 ± 28	358 ± 100	458 ± 39	257 ± 19	328 ± 78	388 ± 23+	248 ± 30		0.001	0.05	
Temperature, rectal	degrees F	99.9 ± .54	99.9 ± .77	100.0 ± .17	100.8 ± .94**	100.1 ± .60	101.5 ± .68***	99.6 ± 0.28	99.7 ± 0.21	99.6 ± 0.40**	0.01	0.05		0.001
Tidal volume	ml	2.20 ± .39	2.51 ± .25	1.89 ± .22	1.78 ± .37**	2.06 ± .31**	1.50 ± .12+	1.86 ± .28	1.91 ± .17+	1.79 ± .43	0.05	0.05	0.05	0.05
Minute volume	ml	215 ± 62	264 ± 43	166 ± 30	185 ± 30	196 ± 34**	174 ± 24	215 ± 28	221 ± 16	207 ± 42		0.001	0.05	
Breathing frequency	breaths per minute	97 ± 18	105 ± 12	88 ± 18	106 ± 17	95 ± 16	116 ± 31	117 ± 14**	116 ± 16	117 ± 13	0.01			
Tidal volume, 6% CO_2	ml	3.14 ± .48	3.50 ± .31	2.78 ± .31	2.80 ± .52	3.21 ± .37	2.39 ± .21**	3.06 ± .38	3.17 ± .35	2.91 ± .43		0.001		0.05
Minute volume, 6% CO_2	ml	419 ± 93	467 ± 106	371 ± 46	388 ± 60	419 ± 47	358 ± 50	428 ± 83	470 ± 85	373 ± 41		0.01		
Breathing frequency, 6% CO_2	b/min	133 ± 22	133 ± 28	134 ± 16	141 ± 20	132 ± 23	149 ± 16	140 ± 21	149 ± 24	129 ± 13				
Blood pressure, systolic	mm Hg	119 ± 6.0	122 ± 7.1	117 ± 3.2	119 ± 7.6	123 ± 6.3	115 ± 6.4	119 ± 6.1	121 ± 7.4	117 ± 3.6		.01		
Heart rate (from blood pressure)	b/min	389 ± 30	383 ± 29	394 ± 33	456 ± 30**	445 ± 34+	467 ± 44+	418 ± 29	417 ± 21	420 ± 44	.001		0.05	0.05
Heart rate (from ECG)	b/min	439 ± 41	432 ± 44	445 ± 39	474 ± 44	464 ± 28	484 ± 57	459 ± 46	440 ± 53	486 ± 16				
ECG - P-wave amplitude	mv	.055 ± .026	.060 ± .027	.050 ± .027	.083 ± .035	.075 ± .022	.090 ± .049	.069 ± .023	.085 ± .010	.047 ± .015				
P-wave duration	sec	.016 ± .002	.017 ± .001	.016 ± .003	.017 ± .001	.018 ± .001	.017 ± .001	.017 ± .001	.017 ± .001	.017 ± .001				
P-P interval	sec	.047 ± .006	.045 ± .004	.049 ± .007	.045 ± .003	.045 ± .002	.045 ± .004	.044 ± .002	.044 ± .002	.043 ± .002				
Q-R-S interval	sec	.016 ± .002	.016 ± .002	.016 ± .001	.016 ± .002	.017 ± .002	.015 ± .002	.016 ± .001	.016 ± .001	.016 ± .000				
Q-T interval	sec	.053 ± .005	.052 ± .005	.053 ± .005	.055 ± .006	.054 ± .007	.055 ± .006	.055 ± .004	.054 ± .005	.055 ± .004				
R-wave amplitude	mv	.24 ± .13	.25 ± .10	.23 ± .17	.36 ± .08	.34 ± .08	.38 ± .08	.24 ± .19	.37 ± .04	.07 ± .15				0.05
T-wave amplitude	mv	.13 ± .05	.12 ± .06	.13 ± .03	.16 ± .05	.15 ± .05	.16 ± .05	.14 ± .04	.16 ± .04	.12 ± .03				
Treadmill run	min	12.6 ± 4.2	10.3 ± 4.9	14.8 ± 1.8	12.8 ± 4.1	12.6 ± 3.8	12.9 ± 4.8	10.9 ± 3.5	11.7 ± 2.5	9.8 ± 5.0				

± Values indicates standard deviation.
* Student's "t" test - different from control at P = 0.01.
** Student's "t" test - different from control at P = 0.05.
*** Student's "t" test - different from control at P = 0.001.

Table B-17. Qualitative Observations on Rats Exposed to White Phosphorous/Felt Smoke

Observation	Number responding					
	Exposure period					
	6 Weeks			13 Weeks		
	Control	Low dose	High dose	Control	Low dose	High dose
Vasomotor reflex	12/12	12/12	6/6	12/12	12/12	7/7
Light reflex	12/12	12/12	6/6	12/12	12/12	7/7
Respiratory response to CO_2	12/12	12/12	6/6	12/12	12/12	7/7
Sniffing response	9/12	12/12	6/6	11/12	12/12	7/7
Moist rales	0/12	0/12	0/6	0/12	0/12	3/12

Table B-18. Pulmonary Responses of Rats Exposed to White Phosphorus/Felt Smoke for 13 Weeks

Condition	Sex	Number of animals	Response (mean and SE)		
			Estimated pulmonary resistance	Respiratory rate	Peak inspiratory flow
			$cmH_2O/l/sec$	resp/min	ml/sec
Control	Male	5	1.03 ± 0.06	179 ± 14.3	24.8 ± 0.92
High dose	Male	4	1.29 ± 0.18	171 ± 2.74	24.7 ± 0.70
Low dose	Male	5	1.75 ± 0.27	142 ± 5.07	24.1 ± 0.55
Control	Female	6	1.58 ± 0.88	120 ± 3.3	22.6 ± 0.90
High dose	Female	3	1.75 ± 0.27	145 ± 26.6	24.2 ± 0.59
Low dose	Female	6	1.33 ± 0.13	134 ± 5.8	23.3 ± 0.72

Table B-19. The Spontaneous Activity Responses of Rats Exposed to White Phosphorus/Felt Smoke

Condition	Sex	Number of animals	Response (mean and SE)		Gross activity / fine activity ratios	
			Gross activity	Fine activity	from individual data	from mean
6-Week exposure						
Control	Female	6	457 ± 143	1680 ± 512	5.12 ± 1.39	3.68
High dose	Female	3	502 ± 21	1739 ± 140	3.49 ± 0.37	3.46
Low dose	Female	6	574 ± 134	1874 ± 353	6.32 ± 3.40	3.20
Control	Male	6	278 ± 122	1093 ± 327	5.10 ± 0.53	3.93
High dose	Male	3	336 ± 65	723 ± 319	1.97 ± 0.37	2.15
Low dose	Male	6	760 ± 109	2253 ± 306	3.07 ± 0.34	2.96
13-Week exposure						
Control	Female	6	608 ± 133	160 ± 300	2.82 ± 0.46	2.65
High dose	Female	3	462 ± 38	1548 ± 149	3.42 ± 0.53	3.35
Low dose	Female	6	575 ± 177	1652 ± 421	3.44 ± 0.46	2.87
Control	Male	6	601 ± 138	1287 ± 176	2.40 ± 0.29	2.14
High dose	Male	4	420 ± 48	1368 ± 308	2.86 ± 0.54	2.91
Low dose	Male	6	450 ± 123	1651 ± 191	3.25 ± 0.23	3.67

Table B-20. The Passive Avoidance Responses of Rats Exposed to White Phosphorus/Felt Smoke

Condition	Sex	Number of animals	Number of passive avoidance responses (mean and SE)	Total number of shocks (mean and SE)	Time in shock (mean and SE)
6-Week exposure					
Control	Female	6	3.3 ± 0.8	8.3 ± 2.8	0.86 ± 0.23
High dose	Female	3	4.7 ± 1.7	8.7 ± 5.6	0.84 ± 0.52
Low dose	Female	6	3.0 ± 1.0	7.0 ± 1.9	0.73 ± 0.19
Control	Male	6	2.7 ± 0.5	6.2 ± 1.9	0.72 ± 0.25
High dose	Male	3	5.3 ± 1.8	10.3 ± 3.3	1.24 ± 0.12
Low dose	Male	6	2.7 ± 0.5	6.0 ± 1.5	1.73 ± 0.32
13-Week exposure					
Control	Female	6	3.7 ± 0.8	9.3 ± 3.2	0.87 ± 0.35
High dose	Female	3	3.0 ± 0.6	10.7 ± 0.6	1.13 ± 0.15
Low dose	Female	6	7.7 ± 3.3	10.2 ± 2.7	1.21 ± 0.32
Control	Male	6	1.8 ± 0.3	7.0 ± 3.1	1.15 ± 0.64
High dose	Male	4	3.8 ± 1.2	25.5 ± 20.9	2.33 ± 1.89
Low dose	Male	6	2.3 ± 0.6	5.3 ± 2.4	0.55 ± 0.27

APPENDIX C

PATHOLOGY REPORT - SPONTANEOUS DEATHS

PATHOLOGY REPORT
PROJECT SMOKE II, WHITE PHOSPHORUS/FELT
INHALATION STUDY - SPONTANEOUS DEATHS
"COLONY" RATS

I. INTRODUCTION.

Six and thirteen week studies designed to assess potential local and systemic toxic effects of inhalation exposure of the agent White Phosphorus/Felt were performed on Edgewood Area Colony Rats. Three dosage levels of the agent were tested. High (1000 mg/m^3) dosage level studies began on 31 July 1978. Medium (500 mg/m^3) dosage level studies began on 7 August 1978. Low (200 mg/m^3) dosage level studies began on 11 September 1978. All rats were approximately six weeks of age at the beginning of the studies and were housed in Bldg E3266.

Of forty-three rats (19 male, 24 female) receiving the high (1000 mg/m^3) dosage level exposure to White Phosphorus/Felt, twenty-nine (15 male, 14 female) died spontaneously during the studies while one control animal and none of the medium or low dose group animals died.

Following necropsy, tissues were imbedded in paraffin and subsequently processed for staining with hematoxylin and eosin. The following tissues were evaluated microscopically: nasal turbinate, larynx, trachea, lungs, heart, esophagus, stomach, small intestine, pancreas, large intestine, liver, adrenal, thyroid, thymus, kidney, bladder, ovary/teste, uterus, mammary gland, prostate, bone marrow, spleen, brain, eye and pituitary.

Histologic findings are tabulated in Tables 1-3. Since one or more tissues from various animals were lost at necropsy or during processing, one must calculate the incidence of lesions based upon the number of tissues examined rather than on the number of animals necropsied.

Two previous reports have been submitted regarding the histopathological findings in the colony rats that completed the six and thirteen week studies. This report deals only with the histopathological findings in those animals that died spontaneously before completing the studies.

II. RESULTS.

The microscopic observations are presented in the Histopathology Incidence Tables.

a. Table 1 tabulates incidence of lesions by organ observed in male and female rats dying spontaneously.

b. Table 2 tabulates incidence and severity of lesions by organ observed in male rats dying spontaneously from the high (1000 mg/m^3) dosage level exposure group.

c. Table 3 tabulates incidence and severity of lesions by organ observed in female rats dying spontaneously from the high (1000 mg/m^3) dosage level exposure group.

III. DISCUSSION.

Numerous sporadically occurring lesions were noted in the high (1000 mg/m^3) dosage level rats that died prior to completion of the White Phosphorus/Felt smoke inhalation studies. Moderate to severe laryngitis was observed in all of nine male rats examined and in five out of six female rats examined. Moderate to severe tracheitis was observed in five out of seven male rats and in all of nine female rats examined. Laryngeal and tracheal lesions often included varying degrees of vessiculation (blistering) and ulceration of the mucosal surfaces. Death of many of these animals probably resulted from asphyxiation produced by mechanical blockage of the larynx/trachea from swelling or from laryngospasm resulting from irritation of the larynx by the smoke. Moderate to severe congestion (hyperemia) was observed in twenty-five out of twenty-nine lungs examined. Irritation produced by the inhaled smoke may be responsible for this finding. A minimal to mild multifocal to diffuse interstitial pneumonia was observed in sixteen out of twenty-nine lungs examined. Peribronchiolar lymphoid aggregates were noted in the lungs of eighteen of twenty-nine animals examined. The interstitial pneumonia and peribronchiolar lymphoid aggregates have been observed historically in colony rats held in this and adjacent animal research facilities. The death of one control rat is attributed to a generalized Phycomycosis (non-contageous fungal agent) involving the gastrointestinal tract, liver and brain.

IV. CONCLUSION.

A high mortality rate was noted in the high (1000 mg/m^3) dosage level exposure group of colony rats being exposed to White Phosphorus/Felt smoke via inhalation exposure. The death of these animals appears to be agent and dose related. A moderate to severe laryngitis/tracheitis accompanied by varying degrees of vessiculation (blistering) and ulceration was observed in most of the animals. Death in these animals probably resulted from asphyxiation produced by mechanical blockage of the larynx/trachea from tissue swelling or from laryngospasm resulting from irritation of the larynx by the smoke. Moderate to severe pulmonary congestion was observed in many of the animals and is probably agent related.

MALCOM N. ALLISON, CPT, VC
Comparative Pathology Branch
Veterinary Medicine Division &
Resources Support Division
US Army Biomedical Laboratory

Project Smoke II
White Phosphorus/Felt
Inhalation Study - Spontaneous Deaths
"Colony" Rats

Key to Microscopic Findings

Table 1

Number of Animals: Represents total number of animals in each group necropsied.

Numbers following tissues represent the number of tissues from each group actually examined.

Numbers following lesions indicate the number of tissues examined showing the particular lesion.

Tables 2-3

- = tissue present

+ = tissue not available for microscopic evaluation

Numbers following organ: Number of specimens examined

Severity of Response

1 = Minimal
2 = Slight
3 = Moderate
4 = Severe
P = Present

STRAIN OF RAT: COLONY
EXPOSURE: VARIABLE
AGENT: WHITE PHOSPHORUS/FELT

TABLE 1 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

		CONTROL		HIGH DOSE	
		M	F	M	F
NUMBER OF ANIMALS		0	1	15	14
NASAL TURBINATE	1/12/11		1	12	11
Rhinitis, Focal					2
LARYNX	1/9/6		1	9	6
Laryngitis				9	5
Submucosal Gland Duct Ectasia					
TRACHEA	0/7/9			7	9
Tracheitis				5	9
Submucosal Gland Duct Ectasia					1
LUNGS	1/15/14		1	15	14
Pneumonia, Interstitial				8	8
Pneumonia, Granulomatous					
Pneumonia, Purulent				1	2
Congestion				12	13
Peribronchiolar Lymphoid Aggregates				9	9
Bronchitis				3	

STRAIN OF RAT: COLONY
EXPOSURE: VARIABLE
AGENT: WHITE PHOSPHORUS/FELT

TABLE 1 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

		CONTROL		HIGH DOSE	
		M	F	M	F
NUMBER OF ANIMALS					
HEART	1/15/14	1		15	14
Myocardial Fibrosis, Focal					
Myocarditis, Focal				2	3
ESOPHAGUS	0/13/13	0		13	13
STOMACH	1/15/14	1		15	14
Gastritis, Acute		1			
SMALL INTESTINE	1/13/13	1		13	13
Enteritis, Acute, Ulcerative		1			
PANCREAS	1/14/14	1		14	14
LARGE INTESTINE	1/14/13	1		14	13
Nematodiasis					
Enteritis, Acute		1			
LIVER	1/14/14	1		14	14
Hepatitis, Focal		1			
Infarct, Lobar					
ADRENAL	1/14/13	1		14	13

STRAIN OF RAT: COLONY
EXPOSURE: VARIABLE
AGENT: WHITE PHOSPHORUS/FELT

TABLE 1 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

		CONTROL		HIGH DOSE	
		M	F	M	F
NUMBER OF ANIMALS					
THYROID	0/10/13	0		10	13
Degeneration				8	11
THYMUS	0/13/7	0		13	7
Hemorrhage, Focal					1
KIDNEY	1/15/14	1		15	14
Hydronephrosis					
Nephritis, Intersitial					2
Glomerulonephritis				2	1
Tubular Mineralization, Focal					5
Tubular Dilitation, Focal					
Proteinuria				4	5
BLADDER	0/9/14	0		9	14
Perivasculitis					
OVARY	0/0/14	0		0	14
UTERUS	1/0/11	1		0	11
Metritis					

STRAIN OF RAT: COLONY
EXPOSURE: VARIABLE
AGENT: WHITE PHOSPHORUS/FELT

TABLE 1 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

		CONTROL		HIGH DOSE	
		M	F	M	F
NUMBER OF ANIMALS					
MAMMARY GLAND	1/0/3	1		0	3
Adenoma					2
Mastitis					
TESTES	0/15/0	0		15	0
PROSTATE	0/11/0	0		11	0
Prostatitis					
MARROW	1/9/8	1		9	8
Granulopoesis, Accelerated					
SPLEEN	1/15/14	1		15	14
Hemosiderosis					4
Lymphoid Depletion		1			
BRAIN	1/15/14	1		15	14
Encephalitis, Pyogranulomatous		1			
Necrosis, Focal					
EYE	1/13/13	1		13	13
PITUITARY	1/7/4	1		7	4
Cyst					1

STRAIN OF RAT: COLONY
EXPOSURE: VARIABLE
DOSE LEVEL: HIGH (1000 MG/M^3)
AGENT: WHITE PHOSPHORUS/FELT

TABLE 2 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

MALE

		78-585	78-609	78-610	78-631	78-634	78-641	78-700	78-701	78-705	78-708	78-718	78-735	78-767	78-781	78-799
NASAL TURBINATE	12	-	-	+	-	+	-	-	-	-	-	-	-	-	-	+
Rhinitis, Focal																
LARYNX	9	+	-	-	-	-	-	+	+	-	+	-	-	+	-	+
Laryngitis			4	4	4	4	4			4		4	4		4	
Submucosal Gland Duct Ectasia													1			
TRACHEA	7	-	-	+	+	+	+	-	-	-	+	+	+	-	+	-
Tracheitis		3						4	4		3					4
Submucosal Gland Duct Ectasia																
LUNGS	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pneumonia, Interstitial		2			2	1	2	2	1		1	1				3
Pneumonia, Granulomatous			2													
Pneumonia, Purulent				3	4	3	3	3	3	3	3	3	3	3	3	3
Congestion		3					2		1		2	1	1	1		2
Peribronchiolar Lymphoid Aggregates																
Bronchitis		2	2					2								

STRAIN OF RAT: COLONY
EXPOSURE: VARIABLE
DOSE LEVEL: HIGH (1000 MG/M^3)
AGENT: WHITE PHOSPHORUS/FELT

TABLE 2 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

MALE

		78-585	78-609	78-610	78-631	78-634	78-641	78-700	78-701	78-705	78-708	78-718	78-735	78-767	78-781	78-799
HEART	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myocardial Fibrosis, Focal										1	2					
Myocarditis, Focal																
ESOPHAGUS	13	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+
STOMACH	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SMALL INTESTINE	13	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+
PANCREAS	14	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
LARGE INTESTINE	14	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Nematodiasis																
Enteritis, Acute																
LIVER	14	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Hepatitis, Focal																
Infarct, Lobar																
ADRENAL	14	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-

STRAIN OF RAT: COLONY
EXPOSURE: VARIABLE
DOSE LEVEL: HIGH (1000 MG/M^3)
AGENT: WHITE PHOSPHORUS/FELT

TABLE 2 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

MALE

		78-585	78-609	78-610	78-631	78-634	78-641	78-700	78-701	78-705	78-708	78-718	78-735	78-767	78-781	78-799
MAMMARY GLAND	0	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Adenoma																
Mastitis																
TESTES	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PROSTATE	11	+	+	+	-	-	-	-	-	-	-	-	-	-	+	-
Prostatitis																
MARROW	9	+	-	+	-	+	+	-	+	-	+	-	-	-	-	-
Granulopoesis, Accelerated																
SPLEEN	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hemosiderosis																
BRAIN	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Encephalitis, Pyogranulomatous																
Necrosis, Focal																
EYE	13	-	-	-	-	-	-	-	+	-	+	+	-	-	-	-
PITUITARY	7	+	+	+	+	+	+	+	-	-	-	+	-	-	-	-
Adenoma																

STRAIN OF RAT: COLONY
EXPOSURE: VARIABLE
DOSE LEVEL: HIGH (1000 MG/M^3)
AGENT: WHITE PHOSPHORUS/FELT

TABLE 2 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

MALE

		78-585	78-609	78-610	78-631	78-634	78-641	78-700	78-701	78-705	78-708	78-718	78-735	78-767	78-781	78-799
THYROID	10	-	-	-	+	+	-	-	-	-	-	+	+	-	+	-
Degeneration		3	2	1			3	3	2					1		4
THYMUS	13	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-
Hemorrhage, Focal																
KIDNEY	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydronephrosis																
Nephritis, Intersitial											3					1
Glomerulonephritis																
Tubular Mineralization, Focal																
Tubular Dilitation, Focal																
Proteinuria		3			2	2					3					
BLADDER	9	-	-	+	-	-	+	+	+	-	-	+	-	+	-	-
Perivasculitis																
OVARY	0	+	+	+	+	+	+	+	+	+	+	+				
UTERUS	0	+	+	+	+	+	+	+	+	+	+	+				
Metritis																

STRAIN OF RAT: COLONY
EXPOSURE: VARIABLE
DOSE LEVEL: HIGH (1000 MG/M^3)
AGENT: WHITE PHOSPHORUS/FELT

TABLE 3 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

FEMALE

		78-583	78-614A	78-614B	78-620	78-621	78-622	78-646	78-642	78-643	78-665	78-703	78-709	78-724	78-797
NASAL TURBINATE	11	-	-	-	-	-	+	-	-	-	+	-	-	+	-
Rhinitis, Focal												3	2		
LARYNX	6	+	+	-	-	+	+	-	-	+	+	-	-	+	+
Laryngitis				4	4			4	4			3			
Submucosal Gland Duct Ectasia															
TRACHEA	9	-	-	+	+	-	-	+	-	-	-	+	+	-	-
Tracheitis		3	4			3	4		4	3	4			4	4
Submucosal Gland Duct Ectasia											2				
LUNGS	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pneumonia, Interstitial			2	2	2			1	1	2		1			2
Pneumonia, Granulomatous															
Pneumonia, Purulent						3	1								
Congestion		1		3	2	4	3	3	3	4	4	3	3	3	3
Peribronchiolar Lymphoid Aggregates			1	1	1		1	1	2	2	2			1	
Bronchitis															

STRAIN OF RAT: COLONY
EXPOSURE: VARIABLE
DOSE LEVEL: HIGH (1000 MG/M^3)
AGENT: WHITE PHOSPHORUS/FELT

TABLE 3 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

FEMALE

		78-583	78-614A	78-614B	78-620	78-621	78-622	78-640	78-642	78-643	78-665	78-703	78-709	78-724	78-797
HEART	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myocardial Fibrosis, Focal															
Myocarditis, Focal		3				2						2			
ESOPHAGUS	13	-	-	-	-	+	-	-	-	-	-	-	-	-	-
STOMACH	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SMALL INTESTINE	13	-	-	-	-	-	-	-	-	-	-	+	-	-	-
PANCREAS	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LARGE INTESTINE	13	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Nematodiasis															
Enteritis, Acute															
LIVER	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hepatitis, Focal															
Infarct, Lobar															
ADRENAL	13	-	-	-	+	-	-	-	-	-	-	-	-	-	-

STRAIN OF RAT: COLONY
EXPOSURE: VARIABLE
DOSE LEVEL: HIGH (1000 MG/M^3)
AGENT: WHITE PHOSPHORUS/FELT

TABLE 3 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

FEMALE

		78-583	78-614A	78-614B	78-620	78-621	78-622	78-640	78-642	78-643	78-665	78-703	78-709	78-724	78-797
THYROID	13	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Degeneration		2	1		2	3	2		1	2		2	2	3	2
THYMUS	7	-	+	+	+	+	-	+	-	-	-	-	+	+	-
Hemorrhage, Focal															
KIDNEY	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydronephrosis															
Nephritis, Intersitial					1				2						
Glomerulonephritis							2								
Tubular Mineralization, Focal		1		1				2		1					2
Tubular Dilitation, Focal															
Proteinuria				1	2	1	3		1						
BLADDER	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Perivasculitis															
OVARY	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UTERUS	11	-	-	-	+	-	-	-	+	-	-	-	-	-	+
Metritis															

STRAIN OF RAT: COLONY
EXPOSURE: VARIABLE
DOSE LEVEL: HIGH (7000 MG/M^3)
AGENT: WHITE PHOSPHORUS/FELT

TABLE 3 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS

SMOKE II

FEMALE

		78-583	78-614A	78-614B	78-620	78-621	78-622	78-640	78-642	78-643	78-665	78-703	78-709	78-724	78-797
MAMMARY GLAND	3	+	+	+	-	+	+	+	+	-	+	+	+	-	+
Adenoma										P	P				
Mastitis															
TESTES	0	+	+	+	+	+	+	+	+	+	+	+	+	+	+
PROSTATE	0	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Prostatitis															
MARROW	8	-	-	+	-	-	-	-	+	-	+	+	+	+	-
Granulopoesis, Accelerated															
SPLEEN	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hemosiderosis		1									1	2	2		
BRAIN	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Encephalitis, Pyogranulomatous															
Necrosis, Focal															
EYE	13	+	-	-	-	-	-	-	-	-	-	-	-	-	-
PITUITARY	4	+	+	+	+	+	+	+	+	+	-	-	-	+	-
Cyst													P		

Appendix C

53

54

APPENDIX D

PATHOLOGY REPORT - 6-WEEK EXPOSURE

Project Smoke II
Inhalation Study Six Weeks
"Colony" Rats

1. Introduction.

The present study was designed to assess potential local and toxic effects following inhalation exposure to White Phosphorus/Felt for a period of fifteen minutes per day, five days a week, for six weeks.

A group of six female rats were exposed by the inhalation route to White Phosphorus/Felt at a high dose level (1000 mg/m^3) and two groups of twelve rats, equally divided as to sex, received intermediate (500 mg/m^3) and low (200 mg/m^3) dosage levels for the prescribed period of time followed by euthanasia. A fourth group of eighteen rats, equally divided as to sex, that were exposed to air only and maintained under similar conditions, served as controls.

At termination and necropsy, tissues were imbedded in paraffin and subsequently processed for staining with hematoxylin and eosin. The following tissues were evaluated microscopically: nasal turbinate, larynx, trachea, lungs, heart, esophagus, stomach, small intestine, pancreas, large intestine, liver, adrenal, thyroid, thymus, kidney, bladder, ovary/teste, uterus, mammary gland, prostate, bone marrow, spleen, brain, eye and pituitary.

2. Results.

The microscopic observations are presented in the Histopathology Incidence Tables.

a. Tables 1-4 tabulate incidence of lesions (by organ) observed in the four groups of male and female colony rats.

b. Tables 5-8 tabulate incidence and severity of lesions (by organ) observed in male and female control rats.

c. Tables 9-12 tabulate incidence of lesions (by organ) observed in each female rat receiving the high dose level exposure to White Phosphorus/Felt.

d. Tables 13-16 tabulate incidence of lesions (by organ) observed in each male and female rat receiving the intermediate dose level exposure to White Phosphorus/Felt.

3. Discussion.

A number of spontaneous lesions were noted in the liver, kidney, thyroid, and pituitary; the lesions occurring with equal severity and frequency in control and White Phosphorus/Felt exposed rats. While none of the control animals displayed laryngitis or tracheitis, all of the laryngeal and tracheal specimens examined from the rats receiving the high dosage level of White Phosphorus/Felt displayed a moderate to severe laryngitis/tracheitis. Fifty percent of the rats receiving intermediate dose levels of White Phosphorus/Felt displayed a minimal to mild tracheitis while one out of three rats had a mild laryngitis. Only one rat receiving the low dose level of White Phosphorus/Felt displayed tracheitis. Four out of six female rats receiving the high dose level of White Phosphorus/Felt displayed minimal to severe interstitial pneumonia while one control rat of each sex displayed a minimal interstitial pneumonia.

4. Conclusion.

The agent, White Phosphorus/Felt, at the dosage levels tested and in the manner tested show a dose related laryngitis and tracheitis. It is suggestive

that high dosage levels of White Phosphorus/Felt may produce interstitial pneumonia in some animals.

MALCOM N. ALLISON, CPT, VC
Comparative Pathology & Surgery Group
Veterinary Medicine Division
US Army Biomedical Laboratory
4 September 1979

Project Smoke II
White Phosphorus Felt
Inhalation Study Six Weeks
"Colony" Rats

Key to Microscopic Findings

Tables 1-4

Number of Animals: Represents total number of animals in each group utilized in the study.

Numbers following tissues represent the number of tissues from each group actually examined.

Numbers following lesion indicate the number of tissues examined showing the particular lesion.

Tables 5-16

- = tissue present
* = tissue not available for microscopic evaluation

Severity of Response

1 = minimal
2 = slight
3 = moderate
4 = severe
P = present

TABLE 1: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
AGENT: WHITE PHOSPHORUS FELT

	CONTROL		HIGH		INTERMEDIATE		LOW	
	M 9	F 9	M 6	F 6	M 6	F 6	M 6	F 6
NUMBER OF ANIMALS	7	8		5	4	3	6	6
NASAL TURBINATE								
Rhinitis, Focal								
	7	4		2	0	3	0	2
LARYNX				2		1		
Laryngitis				1		1		1
Submucosal Gland Duct Ectasia	3	2						
	3	7		4	6	4	6	3
TRACHEA				4	3	2	1	
Tracheitis							3	1
Submucosal Gland Duct Ectasia		2						
	9	9		6	6	6	6	6
LUNGS	1	1		4	2	1	1	
Pneumonia, Interstitial								
Pneumonia, Granulomatous				1			2	
Pneumonia, Purulent				1	2			
Congestion	6	4		3	5	5	3	5
Peribronchiolar Lymphoid Aggregates				3				
Bronchitis								

TABLE 2: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
AGENT: WHITE PHOSPHORUS FELT

	CONTROL		HIGH		INTERMEDIATE		LOW	
NUMBER OF ANIMALS	M 9	F 9	M 0	F 6	M 6	F 6	M 6	F 6
HEART	9	9		6	6	6	6	6
Myocardial Fibrosis, Focal		1			1			
Myocarditis, Focal	3						1	
ESOPHAGUS	9	8		5	6	6	6	6
STOMACH	9	9		6	6	5	5	6
SMALL INTESTINE	9	9		5	6	6	6	4
PANCREAS	9	9		6	5	5	6	6
LARGE INTESTINE	9	9		6	6	4	6	6
Nematodiasis	1				1			
Enteritis, Acute								
LIVER	9	9		6	6	6	6	6
Hepatitis, Focal		3						
Infarct, Lobar								
ADRENAL	9	9		6	5	5	6	6

TABLE 3: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II, 6 WEEKS EXPOSURE.

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
AGENT: WHITE PHOSPHORUS FELT

	CONTROL		HIGH		INTERMEDIATE		LOW	
NUMBER OF ANIMALS	M 9	F 9	M 0	F 6	M 6	F 6	M 6	F 6
THYROID	8	7		4	5	3	5	6
Degeneration	7	4		2	3	2	2	3
THYMUS	9	7		4	5	5	5	5
Hemorrhage, Focal								
KIDNEY	9	9		6	6	6	6	6
Hydronephrosis	1	1						
Nephritis, Intersitiial		1		1				
Glomerulonephritis								
Tubular Mineralization, Focal		6		5		5	1	2
Tubular Dilitation, Focal		1						
Proteinuria	1	1			1			1
BLADDER	7	7		3				
Perivasculitis								
OVARY	0	9		6		5	0	6
UTERUS		8		6		4	0	4
Metritis				1				

TABLE 4: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II, 6 WEEKS EXPOSURE

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
AGENT: WHITE PHOSPHORUS FELT

	CONTROL		HIGH		INTERMEDIATE		LOW	
	M	F	M	F	M	F	M	F
NUMBER OF ANIMALS	9	9	0	6	6	6	6	6
MAMMARY GLAND	0	2		3	0	4	0	1
Adenoma								
Mastitis								
TESTES	9	0		0	6	0	6	0
PROSTATE	9	0		0	4	0	6	0
Prostatitis								
MARROW	6	8		5	4	6	6	6
Granulopoesis, Accelerated	1			1		2		
SPLEEN	9	8		6	6	6	6	6
Hemosiderosis		4		2		3		1
BRAIN	9	9		6	5	6	6	6
Encephalitis, Pyogranulomatous								
Necrosis, Focal								
EYE	7	9		5	5	5	5	6
PITUITARY	5	7		6	4	4	6	6
Adenoma		1						

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
DOSE LEVEL: Control
NECROPSY NO: 78-800/801/731/730/745/746
AGENT: WHITE PHOSPHORUS FELT

TABLE 5: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II, 6 WEEKS EXPOSURE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
NASAL TURBINATE	-	*	-	-	-	-	*	-	-		-	-	-	-	-	-	*	-	-	
Rhinitis, Focal																				
LARYNX	*	-	*	-	-	-	-	-	-		*	*	-	*	*	-	-	-	*	
Laryngitis																				
Submucosal Gland Duct Ectasia							1	3	1				3			2				
TRACHEA	-	-	-	*	*	*	*	*	*		-	-	*	*	-	-	-	-	-	
Tracheitis																				
Submucosal Gland Duct Ectasia															1			1		
LUNGS	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	
Pneumonia, Interstitial						2							2							
Pneumonia, Granulomatous																				
Pneumonia, Purulent																				
Congestion																				
Peribronchiolar Lymphoid Aggregates				1	1	1	1	1	1		1		1		1		1			
Bronchitis																				

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
DOSE LEVEL: Control
NECROPSY NO: 78-800/801/731/730/745/746
AGENT: WHITE PHOSPHORUS FELT

TABLE 6: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II, 6 WEEKS EXPOSURE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
HEART	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	
Myocardial Fibrosis, Focal													2							
Myocarditis, Focal	2						1	1												
ESOPHAGUS	-	-	-	-	-	-	-	-	-		-	*	-	-	*	-	-	-	-	
STOMACH	-	-		-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	
SMALL INTESTINE	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	
PANCREAS	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	
LARGE INTESTINE	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	
Nematodiasis						P														
Enteritis, Acute																				
LIVER	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	
Hepatitis, Focal											1	1	1							
Infarct, Lobar																				
ADRENAL	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
DOSE LEVEL: Control
NECROPSY NO: 78-800/801/731/730/745/746
AGENT: WHITE PHOSPHORUS FELT

TABLE 7: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II, 6 WEEKS EXPOSURE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
THYROID	*	-	-	-	-	-	-	-	-		-	*	-	-	-	*	-	-	-	
Degeneration		4	3	3	1		2	2	2				4	2			4		3	
THYMUS	-	-	-	-	-	-	-	-	-		-	*	*	-	-	-	-	-	-	
Hemorrhage, Focal																				
KIDNEY	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	
Hydronephrosis							3					2							2	
Nephritis, Intersitial																				
Glomerulonephritis												2			1	1	1	1	1	
Tubular Mineralization, Focal													1							
Tubular Dilitation, Focal						1					1									
Proteinuria																				
BLADDER	*	-	-	-	-	*	-	-	-		-	-	-	-	-	*	*	-	-	
Perivasculitis																				
OVARY											-	-	-	-	-	-	-	-	-	
UTERUS											*	-	-	-	-	-	-	-	-	
Metritis																				

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
DOSE LEVEL: Control
NECROPSY NO: 78-800/801/731/730/745/746
AGENT: WHITE PHOSPHORUS FELT

TABLE 8: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II, 6 WEEKS EXPOSURE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
MAMMARY GLAND											*	*	*	*	-	*	*	*	-	
Adenoma																				
Mastitis																				
TESTES	-	-	-	-	-	-	-	-	-											
PROSTATE	-	-	-	-	-	-	-	-	-											
Prostatitis																				
MARROW	*	-	-	-	-	-	*	*	-		-	-	*	-	-	-	-	-	-	
Granulopoesis, Accelerated		2																		
SPLEEN	-	-	-	-	-	-	-	-	-		*	-	-	-	-	-	-	-	-	
Hemosiderosis												2	2	1					2	
BRAIN	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	
Encephalitis, Pyogranulomatous																				
Necrosis, Focal																				
EYE	*	-	-	-	*	-	-	-	-		-	-	-	-	-	-	-	-	-	
PITUITARY	*	*	*	-	-	*	-	-	-		-	*	-	*	-	-	-	-	-	
Adenoma													P							

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
DOSE LEVEL: High
NECROPSY NO: 78-728/729
AGENT: WHITE PHOSPHORUS FELT

TABLE 9: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II., 6 WEEKS EXPOSURE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
NASAL TURBINATE											-	-	-	*	-	-				
Rhinitis, Focal																				
											-	*	*	*	*	-				
LARYNX											3					3				
Laryngitis											3									
Submucosal Gland Duct Ectasia																				
											*	*	-	-	-	-				
TRACHEA													3	3	4	4				
Tracheitis																				
Submucosal Gland Duct Ectasia																				
											-	-	-	-	-	-				
LUNGS											3		4		3	1				
Pneumonia, Interstitial																				
Pneumonia, Granulomatous														2						
Pneumonia, Purulent																3				
Congestion													2		2	1				
Peribronchiolar Lymphoid																				
Aggregates											2	2	2							
Bronchitis																				

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
DOSE LEVEL: High
NECROPSY NO: 78-728/729
AGENT: WHITE PHOSPHORUS FELT

TABLE 10: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II, 6 WEEKS EXPOSURE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
HEART											-	-	-	-	-	-				
Myocardial Fibrosis, Focal														1						
Myocarditis, Focal																				
ESOPHAGUS											*	-	-	-	-	-				
STOMACH											-	-	-	-	-	-				
SMALL INTESTINE											*	-	-	-	-	-				
PANCREAS											-	-	-	-	-	-				
LARGE INTESTINE											-	-	-	-	-	-				
Nematodiasis																				
Enteritis, Acute																				
LIVER											-	-	-	-	-	-				
Hepatitis, Focal																				
Infarct, Lobar																				
ADRENAL											-	-	-	-	-	-				

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
DOSE LEVEL: High
NECROPSY NO: 78-728/729
AGENT: WHITE PHOSPHORUS FELT

TABLE 11: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II 6 WEEKS EXPOSURE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
THYROID											*	*	-	-	-	-				
Degeneration													1		1					
THYMUS											-	*	-	-	-	*				
Hemorrhage, Focal																				
KIDNEY											-	-	-	-	-	-				
Hydronephrosis																				
Nephritis, Intersitial											1									
Glomerulonephritis																				
Tubular Mineralization, Focal											1	1	1		1	1				
Tubular Dilitation, Focal																				
Proteinuria																				
BLADDER											-	*	*	-	*	-				
Perivasculitis																				
OVARY											-	-	-	-	-	-				
UTERUS											-	-	-	-	-	-				
Metritis													1							

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
DOSE LEVEL: High
NECROPSY NO: 78-728/729
AGENT: WHITE PHOSPHORUS FELT

TABLE 12: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II, 6 WEEKS EXPOSURE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
MAMMARY GLAND											*	-	*	*	-	-				
Adenoma																				
Mastitis																				
TESTES											*	*	*	*	*	*				
PROSTATE											*	*	*	*	*	*				
Prostatitis																				
MARROW											-	-	*	-	-	-				
Granulopoesis, Accelerated																2				
SPLEEN											-	-	-	-	-	-				
Hemosiderosis														1	1					
BRAIN											-	-	-	-	-	-				
Encephalitis, Pyogranulomatous																				
Necrosis, Focal																				
EYE											-	-	-	-	*	-				
PITUITARY											-	-	-	-	-	-				
Adenoma																				

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
DOSE LEVEL: Intermediate
NECROPSY NO: 78-747/748
AGENT: WHITE PHOSPHORUS FELT

TABLE 13: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II, 6 WEEKS EXPOSURE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
NASAL TURBINATE	-	*	-	*	-	-					-	-	*	*	-	*				
Rhinitis, Focal																				
LARYNX	*	*	*	*	*	*					-	-	*	-	*	*				
Laryngitis														2						
Submucosal Gland Duct Ectasia														3						
TRACHEA	-	-	-	-	-	-					-	*	-	*	-	-				
Tracheitis		2	1		2						2					1				
Submucosal Gland Duct Ectasia																				
LUNGS	-	-	-	-	-	-					-	-	-	-	-	-				
Pneumonia, Interstitial					1	3						4								
Pneumonia, Granulomatous																				
Pneumonia, Purulent																				
Congestion			3	2																
Peribronchiolar Lymphoid Aggregates		1	1	1	2	1					1		1	1	1	1				
Bronchitis																				

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
DOSE LEVEL: Intermediate
NECROPSY NO: 78-747/748
AGENT: WHITE PHOSPHORUS FELT

TABLE 14: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II, 6 WEEKS EXPOSURE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
HEART	-	-	-	-	-	-					-	-	-	-	-	-				
Myocardial Fibrosis, Focal						2														
Myocarditis, Focal																				
ESOPHAGUS	-	-	-	-	-	-					-	-	-	-	-	-				
STOMACH	-	-	-	-	-	-					-	-	-	-	-	*				
SMALL INTESTINE	-	-	-	-	-	-					-	-	-	-	-	-				
PANCREAS	-	-	-	-	*	-					-	*	-	-	-	-				
LARGE INTESTINE	-	-	-	-	-	-					-	-	-	-	*	*				
Nematodiasis		P																		
Enteritis, Acute																				
LIVER	-	-	-	-	-	-					-	-	-	-	-	-				
Hepatitis, Focal																				
Infarct, Lobar																				
ADRENAL	-	-	*	-	-	-					-	-	*	-	-	-				

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
DOSE LEVEL: Intermediate
NECROPSY NO: 78-747/748
AGENT: WHITE PHOSPHORUS FELT

TABLE 15: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II, 6 WEEKS EXPOSURE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
THYROID	-	-	*	-	-	-					-	*	*	*	-	-				
Degeneration				4	3	2									4	3				
THYMUS	*	-	-	-	-	-					-	-	-	-	-	*				
Hemorrhage, Focal			1																	
KIDNEY	-	-	-	-	-	-					-	-	-	-	-	-				
Hydronephrosis																				
Nephritis, Intersitial																				
Glomerulonephritis												2	1	2	1	1				
Tubular Mineralization, Focal																				
Tubular Dilitation, Focal					1															
Proteinuria																				
BLADDER	*	*	*	-	-	-					-	*	-	*	-	*				
Perivasculitis																				
OVARY											-	-	*	-	-	-				
UTERUS											-	-	-	*	-	*				
Metritis																				

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
DOSE LEVEL: Intermediate
NECROPSY NO: 78-747/748
AGENT: WHITE PHOSPHORUS FELT

TABLE 16: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II, 6 WEEKS EXPOSURE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
MAMMARY GLAND											*	-	-	*	*	*				
Adenoma																				
Mastitis																				
TESTES	-	-	-	-	-	-														
PROSTATE	-	*	-	-	-	*														
Prostatitis																				
MARROW	-	-	*	-	-	*					-	-	-	-	-	-				
Granulopoesis, Accelerated													3			2				
SPLEEN	-	-	-	-	-	-					-	-	-	-	-	-				
Hemosiderosis											1	1				1				
BRAIN	-	-	*	-	-	-					-	-	-	-	-	-				
Encephalitis, Pyogranulomatous																				
Necrosis, Focal																				
EYE	-	-	*	-	-	-					-	-	-	-	-	*				
PITUITARY	-	-	*	*	-	-					-	-	*	*	-	-				
Adenoma																				

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
DOSE LEVEL: Low
NECROPSY NO: 78-796/798
AGENT: WHITE PHOSPHORUS FELT

TABLE 17: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS SMOKE II, 6 WEEKS EXPOSURE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
NASAL TURBINATE	-	-	-	-	-	-					-	-	-	-	-	-				
Rhinitis, Focal																				
LARYNX	*	*	*	*	*	*					*	*	-	-	*	*				
Laryngitis																				
Submucosal Gland Duct Ectasia																				
TRACHEA	-	-	-	-	-	-					-	-	*	*	*	-				
Tracheitis				2																
Submucosal Gland Duct Ectasia		2		2		2						1								
LUNGS	-	-	-	-	-	-					-	-	-	-	-	-				
Pneumonia, Interstitial				2																
Pneumonia, Granulomatous																				
Pneumonia, Purulent																				
Congestion																				
Peribronchiolar Lymphoid		1	1	2							1	1	1		1	1				
Aggregates																				
Bronchitis																				

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
DOSE LEVEL: Low
NECROPSY NO: 78-796/798
AGENT: WHITE PHOSPHORUS FELT

TABLE 18: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II, 6 WEEKS EXPOSURE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
HEART	-	-	-	-	-	-					-	-	-	-	-	-				
Myocardial Fibrosis, Focal																				
Myocarditis, Focal			1																	
ESOPHAGUS	-	-	-	-	-	-					-	-	-	-	-	-				
STOMACH	-	-	-	*	-	-					-	-	-	-	-	-				
SMALL INTESTINE	-	-	-	-	-	-					-	-	-	*	-	-				
PANCREAS	-	-	-	-	-	-					-	-	-	-	-	-				
LARGE INTESTINE	-	-	-	-	-	-					-	-	-	-	-	-				
Nematodiasis																				
Enteritis, Acute																				
LIVER	-	-	-	-	-	-					-	-	-	-	-	-				
Hepatitis, Focal																				
Infarct, Lobar																				
ADRENAL	-	-	-	-	-	-					-	-	-	-	-	-				

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
DOSE LEVEL: Low
NECROPSY NO: 78-796/798
AGENT: WHITE PHOSPHORUS FELT

TABLE 19: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II, 6 WEEKS EXPOSURE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
THYROID	-	-	*	-	-	-					-	-	-	-	-	-				
Degeneration		3		2							3	1			2					
THYMUS	*	-	-	-	-	-					-	-	-	-	*	-				
Hemorrhage, Focal																				
KIDNEY	-	-	-	-	-	-					-	-	-	-	-	-				
Hydronephrosis																				
Nephritis, Intersitial																				
Glomerulonephritis													2			1				
Tubular Mineralization, Focal		1																		
Tubular Dilitation, Focal											1									
Proteinuria																				
BLADDER	-	*	*	-	*	*					-	-	*	*	-	*				
Perivasculitis																				
OVARY											-	-	-	-	-	-				
UTERUS											.	-	*	*	-	-	-			
Metritis																				

STRAIN OF RAT: COLONY
WEEKS EXPOSURE: 6
DAYS POST EXPOSURE: 1
DOSE LEVEL: Low
NECROPSY NO: 78-796/798
AGENT: WHITE PHOSPHORUS FELT

TABLE 20: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II, 6 WEEKS EXPOSURE

	MALE										FEMALE									
	A	B	C	D	E	F	G	H	I	J	A	B	C	D	E	F	G	H	I	J
MAMMARY GLAND											*	*	-	*	*	*				
Adenoma																				
Mastitis																				
TESTES	-	-	-	-	-	-														
PROSTATE	-	-	-	-	-	-														
Prostatitis																				
MARROW	-	-	-	-	-	-					-	-	-	-	-	-				
Granulopoesis, Accelerated																				
SPLEEN	-	-	-	-	-	-					-	-	-	-	-	-				
Hemosiderosis											1									
BRAIN	-	-	-	-	-	-					-	-	-	-	-	-				
Encephalitis, Pyogranulomatous																				
Necrosis, Focal																				
EYE	-	-	-	-	-	*					-	-	-	-	-	-				
PITUITARY	-	-	-	-	-	-					-	-	-	-	-	-				
Adenoma																				

APPENDIX E

PATHOLOGY REPORT - 13-WEEK EXPOSURE

PATHOLOGY REPORT
PROJECT SMOKE II, WHITE PHOSPHORUS/FELT
INHALATION STUDY - THIRTEEN WEEKS
"COLONY" RATS

I. INTRODUCTION.

The study was designed to assess potential local and systemic toxic effects on Edgewood Area Colony rats following inhalation exposure in a chamber to White Phosphorus/Felt for a period of fifteen minutes per day, five days a week, for thirteen weeks. Three separate dosage levels were studied with each dosage level beginning on a different date and having a separate set of control animals receiving sham treatment and housing under similar conditions. All animals were approximately six weeks of age at the beginning of each study. The exposures and animal holding were performed in Bldg E3266.

Exposure of the high dose (1000 mg/m^3) group began on 31 July and ended on 31 October 1978. The exposed group consisted of eight animals, four of each sex. A separate group of three male and three female controls were utilized. Exposure of the medium dose (500 mg/m^3) group began on 7 August 1978 and ended on 7 November of that year. Twelve rats, six of each sex, were exposed to the agent. Three male and three female control rats were utilized in this study. Exposure of the low dose (200 mg/m^3) began on 11 September 1978 and ended on 12 December of the same year. A group of twelve animals, six of each sex, were exposed to the agent. Three male and three female controls were utilized in the study.

In addition to the above animals, a total of four rats, two of each sex, that had been exposed with the high dose group and utilized in physiology studies for eight days were necropsied. No controls were submitted with this group of animals. These animals were included separately in Tables 17-20, but are not considered part of the study in interpreting pathology findings.

Following necropsy, tissues were imbedded in paraffin and subsequently processed for staining with hematoxylin and eosin. The following tissues were evaluated microscopically: nasal turbinate, larynx, trachea, lungs, heart, esophagus, stomach, small intestine, pancreas, large intestine, liver, adrenal, thyroid, thymus, kidney, bladder, ovary/teste, uterus, mammary gland, prostate, bone marrow, spleen, brain, eye and pituitary.

Histologic findings are tabulated in Tables 1-20. Since one or more tissues from various animals were lost at necropsy or during processing, one must calculate the incidence of lesions based upon the number of tissues examined rather than on the number of animals necropsied.

II. RESULTS.

The microscopic observations are presented in the Histopathology Incidence Tables.

a. Tables 1-4 tabulate incidence of lesions (by organ) observed in the six groups of male and female colony rats utilized in the three studies.

b. Tables 5-8 tabulate incidence and severity of lesions (by organ) observed in male and female control rats.

c. Tables 9-12 tabulate incidence of lesions (by organ) observed in each male and female rat receiving the high dose (1000 mg/m^3) level exposure to White Phosphorus/Felt.

d. Tables 13-16 tabulate incidence of lesions (by organ) observed in each male and female rat receiving the medium dose (500 mg/m^3) level exposure.

e. Table 17-20 tabulate incidence of lesions (by organ) observed in each male and female rat receiving the low dose (200 mg/m^3) level exposure.

III. DISCUSSION.

A number of spontaneous lesions were noted in the liver, kidney, thyroid, spleen, heart, uterus, bladder, mammary glands and large intestine. The lesions occurred either sporadically or with equal frequency and severity in both control and White Phosphorus/Felt exposed rats. While none of the control rats displayed laryngitis or tracheitis, all of the male rats receiving the high dosage level of White Phosphorus/Felt exhibited a moderate laryngitis. Of the female rats receiving the same dosage level (1000 mg/m^3) of White Phosphorus/Felt, one of two larynges examined displayed a moderate laryngitis while two out of three tracheae displayed mild to moderate tracheitis. Three out of six female rats receiving the medium dosage level of White Phosphorus/Felt displayed a moderate tracheitis while three out of five male rats receiving the same level exposure displayed slight to moderate tracheitis. None of the low dosage level animals displayed laryngitis or tracheitis.

IV. CONCLUSION.

Though the small number of tissues examined prevents a definitive conclusion, it appears that the agent, White Phosphorus/Felt produces a dose related laryngitis and tracheitis when rats are exposed in the manner tested.

MALCOM N. ALLISON, CPT, VC
Comparative Pathology Group
Veterinary Medicine Division
US Army Biomedical Laboratory

Project Smoke II
White Phosphorus/Felt
Inhalation Study - Thirteen Weeks
"Colony" Rats

Key to Microscopic Findings

Tables 1-4

Number of Animals: Represents total number of animals in each group utilized in the study.

Numbers following tissues represent the number of tissues from each group actually examined.

Numbers following lesions indicate the number of tissues examined showing the particular lesion.

Tables 5-20

- = tissue present

+ = tissue not available for microscopic evaluation

Numbers Following Organs: First number is number of tissues from males examined, second number is number of tissues from females.

Severity of Response

1 = Minimal
2 = Slight
3 = Moderate
4 = Severe
P = Present

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
AGENT: White Phosphorus/Felt

TABLE 7 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

	HIGH DOSE				MEDIUM DOSE				LOW DOSE			
	CONTROL		EXPOSED		CONTROL		EXPOSED		CONTROL		EXPOSED	
	M	F	M	F	M	F	M	F	M	F	M	F
NUMBER OF ANIMALS	3	3	4	4	3	3	6	6	3	3	6	6
NASAL TURBINATE	3	2	3	3	3	2	4	6	2	3	6	6
Rhinitis, Focal												
	3	2	2	2	0	1	0	0	2	0	1	4
LARYNX			2	1								
Laryngitis												4
Submucosal Gland Duct Ectasia	1	1										
	1	2	0	3	3	3	5	6	3	3	5	4
TRACHEA				2			3	3				
Tracheitis										1	1	
Submucosal Gland Duct Ectasia												
	3	3	4	4	3	3	6	6	3	3	6	6
LUNGS		1	1	1		1		1		1		3
Pneumonia, Interstitial												
Pneumonia, Granulomatous												
Pneumonia, Purulent												
Congestion	3	1		2	3	2	5	6	3	2	4	5
Peribronchiolar Lymphoid												
Aggregates												
Bronchitis												

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
AGENT: White Phosphorus/Felt

TABLE 2 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

	HIGH DOSE				MEDIUM DOSE				LOW DOSE			
	CONTROL		EXPOSED		CONTROL		EXPOSED		CONTROL		EXPOSED	
	M	F	M	F	M	F	M	F	M	F	M	F
NUMBER OF ANIMALS	3	3	4	4	3	3	6	6	3	3	6	6
HEART	3	3	4	4	3	3	6	6	3	3	6	6
Myocardial Fibrosis, Focal												
Myocarditis, Focal			1				3		2			
ESOPHAGUS	3	3	3	3	3	3	4	6	3	3	5	4
STOMACH	2	3	4	4	3	2	6	6	3	3	6	6
SMALL INTESTINE	3	3	3	4	3	3	5	4	2	3	6	6
PANCREAS	3	3	4	4	3	2	5	6	3	3	6	6
LARGE INTESTINE	1	3	3	1	3	3	6	6	2	3	6	6
Nematodiasis							1					
Enteritis, Acute												
LIVER	3	3	4	4	3	3	5	6	3	3	6	6
Hepatitis, Focal	1		1	1			1	1				
Infarct, Lobar												
ADRENAL	3	3	3	4	2	2	6	6	3	3	6	6

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
AGENT: White Phosphorus/Felt

TABLE 3 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

	HIGH DOSE				MEDIUM DOSE				LOW DOSE			
	CONTROL		EXPOSED		CONTROL		EXPOSED		CONTROL		EXPOSED	
	M	F	M	F	M	F	M	F	M	F	M	F
NUMBER OF ANIMALS	3	3	4	4	3	3	6	6	3	3	6	6
THYROID	3	3	3	2	3	2	5	6	3	2	4	4
Degeneration	3	3	1		3	2	5	6	2	1	4	4
THYMUS	2	3	4	3	3	3	5	5	3	3	6	6
Hemorrhage, Focal												
KIDNEY	3	3	4	4	3	3	6	6	3	3	6	6
Hydronephrosis												
Nephritis, Interstitial		1				1				1		
Glomerulonephritis												
Tubular Mineralization, Focal		1		3		1		2		3		3
Tubular Dilitation, Focal								1				
Proteinuria		1					2				1	1
BLADDER	1	1	4	4	0	1	5	2	3	1	5	4
Perivasculitis												
OVARY	0	2	0	3	0	3	0	5	0	3	0	6
UTERUS	0	2	0	4	0	2	0	4	0	3	0	5
Metritis								1		1		

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
AGENT: White Phosphorus/Felt

TABLE 4 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

	HIGH DOSE				MEDIUM DOSE				LOW DOSE			
	CONTROL		EXPOSED		CONTROL		EXPOSED		CONTROL		EXPOSED	
	M	F	M	F	M	F	M	F	M	F	M	F
NUMBER OF ANIMALS	3		4	4	3	3	6	6	3	3	6	6
MAMMARY GLAND	0	0	0	0	2		0	3	0	3	0	3
Adenoma												
Mastitis												
TESTES	3	0	4	0	3	0	6	0	3	0	6	0
PROSTATE	0	0	4	0	3	0	6	0	3	0	6	0
Prostatitis									2			
MARROW	3	2	4	3	3	3	5	6	3	3	6	6
Granulopoesis, Accelerated												
SPLEEN	2	2	4	4	3	3	6	5	2	3	6	5
Hemosiderosis		2	3	3			3	4		3		4
BRAIN	3	3	4	4	3	2	6	6	3	3	6	6
Encephalitis, Pyogranulomatous												
Necrosis, Focal												
EYE	3	3	4	4	3	3	6	5	3	3	6	6
PITUITARY	2	2	3	3	3	2	6	6	3	3	6	6
Adenoma												

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
DOSE LEVEL: Control
AGENT: White Phosphorus/Felt

TABLE 5 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

	MALE									FEMALE								
	HIGH			MED			LOW			HIGH			MED			LOW		
	78-833			78-870			78-959			78-834			78-872			78-960		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
NASAL TURBINATE	-	-	-	-	-	-	-	+	-	+	-	-	-	+	-	-	-	-
Rhinitis, Focal																		
LARYNX	-	-	-	-	+	+	-	-	+	-	+	-	-	+	+	+	+	+
Laryngitis																		
Submucosal Gland Duct Ectasia			2							2								
TRACHEA	+	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Tracheitis																		
Submucosal Gland Duct Ectasia																	T	
LUNGS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pneumonia, Interstitial								2				2			T			2
Pneumonia, Granulomatous																		
Pneumonia, Purulent																		
Congestion																		
Peribronchiolar Lymphoid	T	T	T	2	T	T	T	T	T		T		T		T	T	.	2
Aggregates																		
Bronchitis																		

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
DOSE LEVEL: Control
AGENT: White Phosphorus/Felt

TABLE 6 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

	MALE												FEMALE											
	HIGH 78-833			MED 78-870			LOW 78-960				HIGH 78-834			MED 78-872			LOW 78-960							
	A	B	C		A	B	C		A	B	C			A	B	C			A	B	C			A	B	C
HEART	-	-	-		-	-	-		-	-	-			-	-	-			-	-	-			-	-	-
Myocardial Fibrosis, Focal									1	1																
Myocarditis, Focal																										
ESOPHAGUS	-	-	-		-	-	-		-	-	-			-	-	-			-	-	-			-	-	-
STOMACH	-	-	+		-	-	-		-	-	-			-	-	-			-	-	+			-	-	-
SMALL INTESTINE	-	-	-		-	-	-		-	+	-			-	-	-			-	-	-			-	-	-
PANCREAS	-	-	-		-	-	-		-	-	-			-	-	-			-	-	+			-	-	-
LARGE INTESTINE	+	-	+		-	-	-		-	+	-			-	-	-			-	-	-			-	-	-
Nematodiasis																										
Enteritis, Acute																										
LIVER	-	-	-		-	-	-		-	-	-			-	-	-			-	-	-			-	-	-
Hepatitis, Focal	1																									
Infarct, Lobar																										
ADRENAL	-	-	-		-	+	-		-	-	-			-	-	-			4	-	-			-	-	-

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
DOSE LEVEL: Control
AGENT: White Phosphorus/Fe't

TABLE 7 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

	MALE												FEMALE											
	HIGH			MED			LOW			HIGH			MED			LOW								
	78-833			78-870			78-959			78-834			78-872			78-960							
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C					
THYROID	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-						
Degeneration	3	3	2	1	1	1		3	4	3	3	2		4	2	3								
THYMUS	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
Hemorrhage, Focal																								
KIDNEY	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-						
Hydronephrosis										1					1			1					
Nephritis, Intersitial																								
Glomerulonephritis																								
Tubular Mineralization, Focal												1	1	1	1	2	1	1						
Tubular Dilitation, Focal																								
Proteinuria												1												
BLADDER	+	-	+	+	+	+	-	-	-	-	+	+	+	+	-	-	+	+						
Perivasculitis																								
OVARY	+	+	+	+	+	+	+	+	+	-	+	-	-	-	-	-	-	-						
UTERUS	+	+	+	+	+	+	+	+	+	-	+	-	-	+	-	-	-	-						
Metritis																1								

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
DOSE LEVEL: Control
AGENT: White Phosphorus/Felt

TABLE 8 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

	MALE									FEMALE								
	HIGH 78-833			MED 78-870			LOW 78-959			HIGH 78-834			MED 78-872			LOW 78-960		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
MAMMARY GLAND	+	+	+	+	-	-	+	+	+	+	+	+	+	-	+	-	-	-
Adenoma																	P	
Mastitis																		
	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+
TESTES																		
	+	+	+	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+
PROSTATE							2		2									
Prostatitis																		
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MARROW								2										
Granulopoesis, Accelerated																		
	-	+	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-
SPLEEN											2	3				2	2	1
Hemosiderosis																		
	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
BRAIN																		
Encephalitis, Pyogranulomatous																		
Necrosis, Focal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EYE	-	-	+	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-
PITUITARY																		
Adenoma																		

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
DOSE LEVEL: High (1000 mg/m^3)
AGENT: White Phosphorus/Felt

TABLE 9 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

*Animals exposed with this group but held for 8 days for physiology studies prior to necropsy; not included in figures at left or in study.	MALE						FEMALE					
	78-831				78-874		78-832				78-875	
	A	B	C	D	*A	*B	A	B	C	D	*A	*B
NASAL TURBINATE 3/3	+	-	-	-	-	-	-	-	+	-	-	-
Rhinitis, Focal												
LARYNX 2/2	-	+	+	-	+	+	-	+	-	+	+	+
Laryngitis	3			3					3			
Submucosal Gland Duct Ectasia												
TRACHEA 0/3	+	+	+	+	-	-	-	-	+	-	-	-
Tracheitis					2			2		3	2	2
Submucosal Gland Duct Ectasia												
LUNGS 4/4	-	-	-	-	-	-	-	-	-	-	-	-
Pneumonia, Interstitial				1			2					
Pneumonia, Granulomatous	1				2				2	1		2
Pneumonia, Purulent												
Congestion								1				
Peribronchiolar Lymphoid	2	2	1	1	2	1					.	1
Aggregates												
Bronchitis							3					

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
DOSE LEVEL: High (1000 mg/m^3)
AGENT: White Phosphorus/Felt

TABLE 10 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

*Animals exposed with this group but held for 8 days for physiology studies prior to necropsy; not included in figures at left or in study.	MALE								FEMALE							
	78-831				78-874				78-832				78-875			
	A	B	C	D	*A	*B			A	B	C	D	*A	*B		
HEART 4/4	-	-	-	-	-	-			-	-	-	-	-	-		
Myocardial Fibrosis, Focal																
Myocarditis, Focal				2												
ESOPHAGUS 3/3	-	-	+	-	-	+			+	-	-	-	-	-		
STOMACH 4/4	-	-	-	-	-	-			-	-	-	-	-	-		
SMALL INTESTINE 3/4	-	-	-	+	-	-			-	-	-	-	-	-		
PANCREAS 4/4	-	-	-	-	-	-			-	-	-	-	-	-		
LARGE INTESTINE 3/1	-	+	-	-	-	-			+	-	+	+	-	-		
Nematodiasis																
Enteritis, Acute																
LIVER	-	-	-	-	-	-			-	-	-	-	-	-		
Hepatitis, Focal						2						1				
Infarct, Lobar																
ADRENAL 3/4	-	-	-	+	-	-			-	-	-	-	-	+		

STRAIN OF RAT: *Colony*
EXPOSURE: 13 wks
DOSE LEVEL: High (1000 mg/m^3)
AGENT: White Phosphorus/Felt

TABLE 11 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

*Animals exposed with this group but held for 8 days for physiology studies prior to necropsy; not included in figures at left or in study.	MALE						FEMALE					
	78-831				78-874		78-832				78-875	
	A	B	C	D	*A	*B	A	B	C	D	*A	*B
THYROID 3/2	-	-	-	+	-	+	+	-	+	-	-	-
Degeneration												
THYMUS 4/3	-	-	-	-	-	-	+	-	-	-	-	-
Hemorrhage, Focal											3	
KIDNEY 4/4	-	-	-	-	-	-	-	-	-	-	-	-
Hydronephrosis												
Nephritis, Intersitial												
Glomerulonephritis												
Tubular Mineralization, Focal							1	1		1	1	1
Tubular Dilitation, Focal												
Proteinuria						2						
BLADDER 4/4	-	-	-	-	-	-	-	-	-	-	+	-
Perivasculitis												
OVARY 0/3					+	+	-	+	-	-	+	+
UTERUS 0/4					+	+	-	-	-	-	+	-
Metritis												

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
DOSE LEVEL: High (1000 mg/m^3)
AGENT: White Phosphorus/Felt

TABLE 12 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

*Animals exposed with this group but held for 8 days for physiology studies prior to necropsy; not included in figures at left or in study.

		MALE						FEMALE					
		78-831				78-874		78-832				78-875	
		A	B	C	D	*A	*B	A	B	C	D	*A	*B
MAMMARY GLAND	0/0					+	+	+	+	+	+	+	-
Adenoma													
Mastitis													
TESTES	4/0	-	-	-	-	-	-					+	+
PROSTATE	4/0	-	-	-	-	-	-					+	+
Prostatitis													
MARROW	4/3	-	-	-	-	-	-	-	+	-	-	-	-
Granulopoesis, Accelerated													
SPLEEN	4/4	-	-	-	-	-	-	-	-	-	-	-	-
Hemosiderosis		1	1	1		1		2	1	3		3	2
BRAIN	4/4	-	-	-	-	-	-	-	-	-	-	-	-
Encephalitis, Pyogranulomatous													
Necrosis, Focal							2						1
EYE	4/4	-	-	-	-	-	-	-	-	-	-	+	+
PITUITARY	3/3	-	+	-	-	+	+	-	+	-	-	-	+
Adenoma													

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
DOSE LEVEL: Medium (500 mg/m^3)
AGENT: White Phosphorus/Felt

TABLE 13 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

		MALE						FEMALE					
		78-869						78-871					
	6/6	A	B	C	D	E	F	A	B	C	D	E	F
NASAL TURBINATE	4/6	-	-	-	-	+	+	-	-	-	-	-	-
Rhinitis, Focal													
LARYNX	0/0	+	+	+	+	+	+	+	+	+	+	+	+
Laryngitis													
Submucosal Gland Duct Ectasia													
TRACHEA	5/6	-	+	-	-	-	-	-	-	-	-	-	-
Tracheitis		1		2			2	3			3	3	
Submucosal Gland Duct Ectasia													
LUNGS	6/6	-	-	-	-	-	-	-	-	-	-	-	-
Pneumonia, Interstitial													
Pneumonia, Granulomatous													
Pneumonia, Purulent													
Congestion													
Peribronchiolar Lymphoid Aggregates		1	1		1	2	1	1	1	1	1	1	1
Bronchitis													

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
DOSE LEVEL: Medium (500 mg/m^3)
AGENT: White Phosphorus/Felt

TABLE 14 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

		MALE						FEMALE					
		78-869						78-877					
	6/6	A	B	C	D	E	F	A	B	C	D	E	F
HEART	6/6	-	-	-	-	-	-	-	-	-	-	-	-
Myocardial Fibrosis, Focal													
Myocarditis, Focal		3			1		3						
ESOPHAGUS	4/6	-	+	-	-	+	-	-	-	-	-	-	-
STOMACH	6/6	-	-	-	-	-	-	-	-	-	-	-	-
SMALL INTESTINE	5/4	-	-	-	-	-	+	-	-	+	-	-	+
PANCREAS	5/6	-	-	-	-	-	+	-	-	-	-	-	-
LARGE INTESTINE	6/6	-	-	-	-	-	-	-	-	-	-	-	-
Nematodiasis				P									
Enteritis, Acute													
LIVER	5/6	+	-	-	-	-	-	-	-	-	-	-	-
Hepatitis, Focal			-						1				
Infarct, Lobar													
ADRENAL	6/6	-	-	-	-	-	-	-	-	-	-	-	-

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
DOSE LEVEL: Medium (500 mg/m^3)
AGENT: White Phosphorus/Felt

TABLE 15 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

		MALE						FEMALE					
		78-869						78-871					
	6/6	A	B	C	D	E	F	A	B	C	D	E	F
THYROID	5/6	-	+	-	-	-	-	-	-	-	-	-	-
Degeneration		2		2	1	4	2	3	2	3	3	3	3
THYMUS	5/5	-	-	-	-	+	-	-	+	-	-	-	-
Hemorrhage, Focal													
KIDNEY	6/6	-	-	-	-	-	-	-	-	-	-	-	-
Hydronephrosis													
Nephritis, Interstitial													
Glomerulonephritis													
Tubular Mineralization, Focal									1	2			
Tubular Dilitation, Focal												2	
Proteinuria			1		1								
BLADDER	5/2	-	-	+	-	-	-	+	-	-	+	+	+
Perivesculitis													
OVARY	0/5							+	-	-	-	-	-
UTERUS	0/5							-	-	-	+	-	-
Metritis										1			

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
DOSE LEVEL: Medium (500 mg/m^3)
AGENT: White Phosphorus/Felt

TABLE [illegible]: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

		MALE												FEMALE											
		78-869												78-871											
	6/6	A	B	C	D	E	F							A	B	C	D	E	F						
MAMMARY GLAND	0/3													-	+	+	+	-	-						
Adenoma																									
Mastitis																									
TESTES	6/0	-	-	-	-	-	-																		
PROSTATE	6/0	-	-	-	-	-	-																		
Prostatitis																									
MARROW	5/6	-	+	-	-	-	-							-	-	-	-	-	-						
Granulopoesis, Accelerated																	+								
SPLEEN	6/5	-	-	-	-	-	-							-	-	-	+	-	-						
Hemosiderosis				1	1	1									2	1		1	1						
BRAIN	6/6	-	-	-	-	-	-							-	-	-	-	-	-						
Encephalitis, Pyogranulomatous																									
Necrosis, Focal																									
EYE	6/5	-	-	-	-	-	-							-	-	-	-	-	+						
PITUITARY	6/6	-	-	-	-	-	-							-	-	-	-	-	-						
Adenoma																									

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
DOSE LEVEL: Low (200 mg/m^3)
AGENT: White Phosphorus/Felt

TABLE 17: MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

		MALE												FEMALE											
		78-957												78-958											
		A	B	C	D	E	F							A	B	C	D	E	F						
NASAL TURBINATE	6/6	-	-	-	-	-	-							-	-	-	-	-	-						
Rhinitis, Focal																									
LARYNX	1/4	+	-	+	+	+	+							+	-	+	-	-	-						
Laryngitis															2										
Submucosal Gland Duct Ectasia															2		1	2	2						
TRACHEA	5/4	-	+	-	-	-	-							-		-	+	-	+						
Tracheitis																									
Submucosal Gland Duct Ectasia					3																				
LUNGS	6/6	-	-	-	-	-	-							-	-	-	-	-	-						
Pneumonia, Interstitial														1	1			2							
Pneumonia, Granulomatous																									
Pneumonia, Purulent																									
Congestion																									
Peribronchiolar Lymphoid		1	1		1	2								1	1	2	1		1						
Aggregates																									
Bronchitis																									

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
DOSE LEVEL: Low (200 mg/m^3)
AGENT: White Phosphorus/Felt

TABLE E5 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

		MALE														FEMALE											
		78-957														78-958											
		A	B	C	D	E	F									A	B	C	D	E	F						
HEART	6/6	-	-	-	-	-	-									-	-	-	-	-	-						
Myocardial Fibrosis, Focal																											
Myocarditis, Focal						1																					
ESOPHAGUS	5/4	-	-	-	+	-	-									-	-	-	+	-	+						
STOMACH	6/6	-	-	-	-	-	-									-	-	-	-	-	-						
SMALL INTESTINE	6/6	-	-	-	-	-	-									-	-	-	-	-	-						
PANCREAS	6/6	-	-	-	-	-	-									-	-	-	-	-	-						
LARGE INTESTINE	6/6	-	-	-	-	-	-									-	-	-	-	-	-						
Nematodiasis																											
Enteritis, Acute																											
LIVER	6/6	-	-	-	-	-	-									-	-	-	-	-	-						
Hepatitis, Focal																			1								
Infarct, Lobar																											
ADRENAL	6/6	-	-	-	-	-	-									-	-	-	-	-	-						

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
DOSE LEVEL: Low (200 mg/m^3)
AGENT: White Phosphorus/Felt

TABLE 19 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

	MALE 78-957						FEMALE 78-958					
	A	B	C	D	E	F	A	B	C	D	E	F
THYROID 4/4	-	+	-	+	-	-	-	+	-	-	-	+
Degeneration	1		2		2	2	2		1	1	2	
THYMUS 6/6	-	-	-	-	-	-	-	-	-	-	-	-
Hemorrhage, Focal												
KIDNEY 6/6	-	-	-	-	-	-	-	-	-	-	-	-
Hydronephrosis												
Nephritis, Intersitial												
Glomerulonephritis												
Tubular Mineralization, Focal												
Tubular Dilitation, Focal												
Proteinuria						1	1					
BLADDER 5/4	-	-	-	+	-	-	-	-	+	-	+	-
Perivasculitis			1									
OVARY 0/6							-	-	-	-	-	-
UTERUS 0/5							-	-	-	-	+	-
Metritis												

STRAIN OF RAT: Colony
EXPOSURE: 13 wks
DOSE LEVEL: Low (200 mg/m^3)
AGENT: White Phosphorus/Felt

TABLE 20 : MICROSCOPIC OBSERVATIONS IN TISSUES FROM COLONY RATS
SMOKE II

		MALE												FEMALE											
		78-957												78-958											
		A	B	C	D	E	F							A	B	C	D	E	F						
MAMMARY GLAND	0/3													+	-	-	+	-	+						
Adenoma																									
Mastitis																									
TESTES	6/0	-	-	-	-	-	-																		
PROSTATE	5/0	-	=	-	-	-	-																		
Prostatitis																									
MARROW	6/6	-	-	-	-	-	-							-	-	-	-	-	-						
Granulopoesis, Accelerated					2																				
SPLEEN	6/6	-	-	-	-	-	-							-	-	-	-	-	-						
Hemosiderosis														2	2		1	1							
BRAIN	6/6	-	-	-	-	-	-							-	-	-	-	-	-						
Encephalitis, Pyogranulomatous																									
Necrosis, Focal																									
EYE	6/6	-	-	-	-	-	-							-	-	-	-	-	-						
PITUITARY		-	-	-	-	-	-							-	-	-	-	-	-						
Adenoma																									

APPENDIX F

PATHOLOGY REPORT - 13-WEEK EXPOSURE AND 4-WEEK RECOVERY PERIOD

PATHOLOGY REPORT
PROJECT SMOKE II, WHITE PHOSPHORUS/FELT
INHALATION STUDY PERFORMED FOR THIRTEEN WEEKS IN
EDGEWOOD COLONY RATS
PROTOCOL NO. PEM 78-7

1. INTRODUCTION.

Male and female Edgewood area colony rats approximately six weeks old were exposed to high (1000 mg/m^3), medium (500 mg/m^3) and low (200 mg/m^3) dose levels of the agent White Phosphorus/Felt in the form of smoke. The above doses were administered 15 minutes a day, 5 days a week for a period of thirteen weeks. Thirty days following final exposure, the rats were killed by intraperitoneal injection of sodium pentobarbital and necropsied. Since each dose group was exposed on different calender dates, separate control groups were utilized with each exposure group. Controls were placed in the exposure chamber for the same length of time each day as the exposed animals. Controls were necropsied concurrently with the exposed groups. All animals were housed in Building E3266 in standard laboratory animal facilities during non-exposure periods. Following necropsy, tissues were fixed in ten percent buffered formalin. The preserved tissues were submitted to the American HistoLab, for imbedding in paraffin, processing, and staining with hematoxylin and eosin. The following tissues from the high dose group and controls were processed for microscopic examination: nasal turbinate, larynx/trachea, lungs, heart, esophagus, salivary gland, stomach, small intestine, pancreas, large intestine, liver, adrenal, thyroid, thymus, kidney, bladder, ovary/testis, uterus, mammary gland, skin, muscle, prostate, bone marrow, bone, spleen, nerve, eye, brain, and pituitary. Turbinates were removed at necropsy for processing. The trachea was sampled from the proximal portion and lungs were sectioned randomly. The respiratory tracts only (target organ) consisting of nasal turbinates, trachea, larynx, and lungs were examined in medium and low dose groups.

2. RESULTS.

Significant findings were limited to the respiratory tract. These data are presented in Tables 1-3. Microscopic diagnoses from all tissues of high dose and control rats are presented in Tables 4-7. Respiratory tract lesions are presented from all other animals in Tables 8-13. Lesions were noted in the larynx or trachea of 15 of 16 high (1000 mg/m^3) dose level rats, 20 of 24 medium dose (500 mg/m^3) level rats and in none of the controls. Pulmonary lesions were noted in 11 of 16 high dose rats, 6 of 24 medium dose rats and none of the controls for these two groups. Although none of the low dose animals exhibited significant lesions, one control (79-0176) for this group did display the same pulmonary lesion as the high and medium dose exposed animals. Lesions were most extensive and severe in the larynx and trachea. They consisted mainly of thickening of the lamina propria and submucosa by collagen, endothelial cell proliferation, and macrophage infiltration. Areas of collagen were tinctorially different and characterized by an amphophilic to basophilic appearance. Epithelioid macrophages with giant cell formation surrounded some of the altered collagen. Overlying epithelium often lacked cilia and was at times thickened and metaplastic. Occassionally, inflammatory cells were seen

in the epithelium. Similar but much less extensive lesions were seen in bronchi and bronchioles. These lesions were characterized by focal areas of altered collagen within the lamina propria. These foci were amphophilic to basophilic in appearance and occassionally surrounded by macrophages and epithelioid giant cells. Small granulomas were noted within respiratory bronchioles. These granulomas often extended into the adjacent lung parenchyma. The granulomas were characterized by swirling configurations of histiocytes and epithelioid macrophages with giant cell formation.

3. DISCUSSION.

A number of incidental lesions were observed in various organs of the high (1000 mg/m^3) dose group. These lesions either occurred sporadically or with equal frequency in both exposed and control animals. Smoke-related lesions were limited to the upper airways and to a lesser extent, the smaller airways of the lung and the parenchyma adjacent to the terminal bronchioles. Since only the respiratory system was involved in the high dose animals, examination was confined to this system in the medium and low dose groups. All lesions attributable to the smoke were of a chronic inflammatory nature, characterized by collagen degeneration, and thickening of the lamina propria and submucosa of airways by fibrovascular proliferations.

Nasal lesions consisting of focal squamous metaplasia and a slight inflammatory cell infiltrate were seen in one high dose animal, accession number 78-910F. It is felt that lesions may have been present in other exposed animals as well; however, the sampling technique precluded our observing this. In light of this, it is recommended that a more systematic approach to studying the upper respiratory tract lesions be followed in subsequent studies.

4. CONCLUSION.

Rats exposed to the agent, White Phosphorus/Felt at the 1000 mg/m^3 and 500 mg/m^3 dosage levels developed a dosage related response characterized by chronic inflammation of the airways; lesions were most severe in the larynx and trachea but also involved the lower areas to a slight degree.

MALCOM N. ALLISON, CPT, VC
Comparative Pathology Branch
Veterinary Medicine & Laboratory
Resources Support Division
US Army Biomedical Laboratory
30 May 1980

REVIEWED BY:

WILLIAM C. HALL, MAJ, VC
U.S. Army
USAMRIID

TABLE 1 MICROSCOPIC OBSERVATIONS FROM RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS EXPOSED TO WHITE PHOSPHORUS/FELT SMOKE FOR 13 WEEKS AND KILLED 30 DAYS POST EXPOSURE

PROTOCOL NO. PEM 78-7

SEX	MALE		FEMALE	
DOSE	1000PPM	CONTROL	1000PPM	CONTROL
ACCESSION NO.	78-910	78-912	78-913	78-914
NO. OF RATS	9	6	7	6
DIAGNOSIS				
Laryngitis/Tracheitis	9	0	6	0
Bronchitis/Bronchiolitis	4	0	2	0
Granulomatous Bronchiolitis/Pneumonia	3	0	2	0

TABLE 2 MICROSCOPIC OBSERVATIONS FROM RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS EXPOSED TO WHITE PHOSPHORUS/FELT SMOKE FOR 13 WEEKS AND KILLED 30 DAYS POST EXPOSURE

PROTOCOL NO. PEM 78-7

SEX	MALE		FEMALE	
DOSE	500PPM	CONTROL	500PPM	CONTROL
ACCESSION NO.	78-926	78-927	78-929	78-930
NO. OF RATS	12	6	12	6
DIAGNOSIS				
Laryngitis/Tracheitis	10	0	10	0
Bronchitis/Bronchiolitis	4	0	1	0
Granulomatous Bronchiolitis/Pneumonia	0	0	1	0

TABLE 3 MICROSCOPIC OBSERVATIONS FROM RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS EXPOSED TO WHITE PHOSPHORUS/FELT SMOKE FOR 13 WEEKS AND KILLED 30 DAYS POST EXPOSURE

PROTOCOL NO. PEM 78-7

SEX	MALE		FEMALE	
DOSE	200PPM	CONTROL	200PPM	CONTROL
ACCESSION NO.	79-017	79-017	79-016	79-018
NO. OF RATS	6	3	6	2
DIAGNOSIS				
Laryngitis/Tracheitis	0	0	0	0
Bronchitis/Bronchiolitis	0	0	0	0
Granulomatous Bronchiolitis/Pneumonia	0	0	0	0

PROTOCOL NO.: PEM 78-7
SEX: MALE
EXPOSURE: CONTROL
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

TABLE 4 MICROSCOPIC OBSERVATIONS IN TISSUES FROM EDGEWOOD AREA COLONY RATS
SMOKE II

ACCESSION NO.	DIAGNOSIS
78-912A	Histocytosis, focal, minimal, pleura, lung, rat Nephrosis, multifocal, minimal to mild, kidney Congestion, minimal, thymus
78-912B	Congestion, mild, lung, rat Hemorrhage and congestion, minimal, thymus
78-912C	Pyelitis, focal, acute, minimal, kidney, rat Hemorrhage and congestion, diffuse, mild, thymus
78-912D	Congestion, multifocal, mild, lung, rat Chronic respiratory disease, minimal, lung & bronchus Congestion and hemorrhage, diffuse, minimal, thymus
78-912E	Congestion, multifocal, mild, lung, rat Chronic respiratory disease, minimal, lung Hemorrhage, multifocal, minimal, thymus
78-912F	Lymphoid infiltrate focal, minimal, subplural, lung, rat Chronic respiratory disease, minimal, lung Congestion, diffuse, minimal, thymus Hemorrhage, multifocal, minimal, thymus Medial calcification, focal, minimal, pulmonary artery

PROTOCOL NO.: PEM 78-7
SEX: FEMALE
EXPOSURE: CONTROL
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

TABLE 5 MICROSCOPIC OBSERVATIONS IN TISSUES FROM EDGEWOOD AREA COLONY RATS
SMOKE II

ACCESSION NO.	DIAGNOSIS
78-914A	Histiocytosis, focal, minimal, lung, rat
	Nephrocalcinosis, minimal, kidney
	Hemorrhage, multifocal, minimal, thymus
78-914B	Congestion, multifocal, mild, lung, rat
	Nephrocalcinosis, minimal, kidney
	Hemorrhage, multifocal, minimal, thymus
78-914C	Nephrocalcinoisis, minimal, kidney, rat
78-914D	Congestion, multifocal, mild, lung, rat
	Retinal atrophy, focal, minimal, eye
	Endocardiosis, valvular, minimal, heart
78-914E	Tracheitis, focal, lymphocytic, minimal, trachea, rat
	Chronic respiratory disease, minimal, lung
	Congestion, focal, minimal, lung
	Granuloma, focal, Hardarian gland
	Congestion, diffuse, moderate, thymus

PROTOCOL NO.: PEM 78-7
SEX: FEMALE
EXPOSURE: CONTROL
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

TABLE 5 MICROSCOPIC OBSERVATIONS IN TISSUES FROM EDGEWOOD AREA COLONY RATS
SMOKE II

ACCESSION NO.	DIAGNOSIS
78-974F	Congestion, focal, minimal, lung, rat
	Congestion and hemorrhage, diffuse, mild, thymus
	Congestion, moderate, lymph node

PROTOCOL NO.: PEM 78-7
SEX: MALE
EXPOSURE: 1000 MG/M^3
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

TABLE 6 MICROSCOPIC OBSERVATIONS IN TISSUES FROM EDGEWOOD AREA COLONY RATS
SMOKE II

ACCESSION NO.	DIAGNOSIS
78-910A	Tracheitis, chronic, diffuse, moderate, trachea, rat Interstitial pneumonia, multifocal, mild, lung Congestion, diffuse, minimal, spleen
78-910B	Tracheitis, chronic, diffuse, mild, trachea, rat Prostatitis, interstitial, subacute, diffuse, minimal-mild, prostate Epicarditis, subacute, focal, mild, rt. ventricle, heart
78-910C	Tracheitis, chronic, diffuse, mild, trachea, rat Prostatitis, interstitial, subacute, diffuse, minimal, prostate Nematodiasis, large intestine, compatible with Oxyuriasis
78-910D	Tracheitis, subacute, diffuse, moderate-severe, trachea, rat Pneumonia, granulomotous, multifocal, minimal, lung Prostatitis, subacute, multifocal, minimal, prostate Congestion, diffuse, minimal, thymus

PROTOCOL NO.: PEM 78-7
SEX: MALE
EXPOSURE: 1000 MG/M^3
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

TABLE 6 MICROSCOPIC OBSERVATIONS IN TISSUES FROM EDGEWOOD AREA COLONY RATS
SMOKE II

ACCESSION NO.	DIAGNOSIS
78-910E	Tracheitis, chronic, multifocal, mild, trachea, rat
	Laryngitis, chronic, multifocal, mild, larynx
	Bronchitis, chronic, multifocal, mild, lung
	Rhinitis, focal, subacute, mild, nasal cavity
	Myocarditis, focal, subacute, minimal, heart
	Congestion, diffuse, mild, spleen
78-910F	Tracheitis, multifocal, chronic, mild, trachea, rat
	Pneumonia, granulmatous, multifocal, minimal, lung
	Bronchitis, multifocal, chronic, minimal, lung
	Prostatitis, interstitial, multifocal, minimal, prostate
	Congestion, and hemorrhage, diffuse, mild, thymus
78-910G	Tracheitis, multifocal, chronic, minimal, trachea, rat
	Bronchiolitis, chronic, multifocal, minimal, lung
	Prostatitis, subacute, multifocal, mild, prostate
78-910H	Laryngitis, chronic, diffuse, minimal, larynx, rat
	Pneumonia, granulomatous, multifocal, minimal, lung
	Hemorrhage, focal, minimal, thymus, rat

PROTOCOL NO.: PEM 78-7
SEX: MALE
EXPOSURE: 1000 MG/M^3
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

TABLE 6 MICROSCOPIC OBSERVATIONS IN TISSUES FROM EDGEWOOD AREA COLONY RATS
SMOKE II

ACCESSION NO.	DIAGNOSIS
78-9101	Laryngitis, diffuse, chronic, mild, larynx, rat
	Pneumonia, granulomatous, multifocal, minimal, lung
	Bronchiolitis, obliterative, focal, lung
	Bronchiolitis, multifocal, chronic, minimal
	Congestion, diffuse, mild, thymus
	Congestion, diffuse, minimal, spleen

PROTOCOL NO.: PEM 78-7
SEX: FEMALE
EXPOSURE: 1000 MG/M^3
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

TABLE 7 MICROSCOPIC OBSERVATIONS IN TISSUES FROM EDGEWOOD AREA COLONY RATS
SMOKE II

ACCESSION NO.	DIAGNOSIS
78-913A	Tracheitis, chronic, multifocal, mild, trachea, rat
	Hemorrhage, multifical, minimal, thymus
	Congestion, multifocal, mild, lung
	Nephrocalcinosis and lithiasis, mild, kidney
78-913B	Laryngitis, multifocal, chronic, mild, larynx, rat
	Bronchitis, multifocal, chronic, minimal, lung
	Pneumonia, granulomatous, focal, minimal, lung
	Nephrocalcinosis, minimal, kidney
	Atrophy, focal, minimal, retina, eye
	Congestion, and hemorrhage, diffuse, minimal, thymus
78-913C	Bronchitis, focal, chronic, minimal, lung, rat
	Congestion, and hemorrhage, diffuse, mild, thymus
	Myocarditis, focal, subacute, minimal, Rt. ventricle, heart
	Nephrocalcinosis, minimal, kidney

PROTOCOL NO.: PEM 78-7
SEX: FEMALE
EXPOSURE: 1000 MG/M^3
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

TABLE 7 MICROSCOPIC OBSERVATIONS IN TISSUES FROM EDGEWOOD AREA COLONY RATS
SMOKE II

ACCESSION NO.	DIAGNOSIS
78-913D	Laryngitis, subacute, multifocal, minimal, larynx, rat
	Histiocytosis, multifocal, minimal, lung
	Hemorrhage, diffuse, moderate, lymph node
	Congestion, and hemorrhage, diffuse, mild, thymus
78-913E	Tracheitis, chronic, focal, minimal, trachea, rat
	Lymphoid infiltrate, focal, minimal, subpleural, lung
	Histiocytosis, focal, minimal, lung, rat
	Congestion, and hemorrhage, diffuse, mild, thymus
	Nephrocalcinosis, minimal, kidney
	Mineralization, focal, minimal, adrenal
78-913F	Tracheitis, focal, chronic, minimal, trachea, rat
	Congestion, diffuse, mild, thymus
	Cyst, thymus
	Hemorrhage, diffuse, moderate, lymph node
	Nephrocalcinosis, mild, kidney

PROTOCOL NO.: PEM 78-7
SEX: FEMALE
EXPOSURE: 1000 MG/M^3
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

TABLE 7 MICROSCOPIC OBSERVATIONS IN TISSUES FROM EDGEWOOD AREA COLONY RATS
SMOKE II

ACCESSION NO.	DIAGNOSIS
78-913G	Laryngitis, multifocal, chronic, minimal, larynx, rat
	Pneumonia, granulomatous, multifocal, minimal, lung
	Chronic respiratory disease, minimal
	Congestion, diffuse, mild, lung
	Medial calcification, multifocal, minimal, pulmonary artery
	Hemorrhage and congestion, thymus

PROTOCOL NO.: PEM 78-7
SEX: MALE
EXPOSURE: CONTROL
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

TABLE 8 MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS
SMOKE II

ACCESSION NO.	DIAGNOSIS
78-927A	Congestion, mild, lung, rat
78-927B	Congestion, mild, lung, rat
78-927C	No significant lesion
78-927D	Medial calcification, focal, minimal, pulmonary artery, rat
78-927E	Congestion, mild, lung, rat Medial calcification, multifocal, minimal, pulmonary artery Chronic respiratory disease, mild, lung
78-927F	Lymphoid infiltrate, focal, minimal, plevra, lung, rat Congestion, minimal, lung

PROTOCOL NO.: PEM 78-7
SEX: MALE
EXPOSURE: 500 MG/M^3
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

TABLE 9 MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS
SMOKE II

ACCESSION NO.	DIAGNOSIS
78-926A	Tracheitis, chronic, diffuse, mild, trachea, rat Bronchiolitis, focal, chronic, minimal, lung Medial calcification, focal, minimal, pulmonary artery, lung
78-926B	No significant lesion
78-926C	Tracheitis, diffuse, chronic, moderate, trachea, rat Bronchitis, focal, chronic, minimal, lung
78-926D	Tracheitis, diffuse, chronic, moderate, trachea, rat Bronchitis, multifocal, chronic, minimal, bronchi Chronic respiratory disease, minimal, lung Medial calcification, multifocal, minimal, pulmonary artery, lung
78-926E	Tracheitis, focal, chronic, moderate, trachea, rat Medial hypertrophy, multifocal, moderate, pulmonary artery, lung
78-926F	Laryngitis, diffuse, chronic, mild, larynx, rat

PROTOCOL NO.: PEM 78-7 TABLE 9 MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS
SMOKE II

SEX: MALE
EXPOSURE: 500 MG/M^3
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

ACCESSION NO.	DIAGNOSIS
78-926G	Tracheitis, diffuse, chronic, moderate, trachea, rat
78-926H	Bronchiolitis, focal, chronic, minimal, lung, rat
78-926I	Tracheitis, multifocal, chronic, moderate, trachea, rat Histiocytosis, multifocal, minimal, lung
78-926J	Laryngitis, multifocal, chronic, minimal, larynx, rat Medial calcification, focal, minimal, pulmonary artery, lung
78-926K	Tracheitis, multifocal, chronic, moderate, trachea, rat
78-926L	Tracheitis, focal, chronic, mild, trachea, rat

PROTOCOL NO.: PEM 78-7 TABLE 10 MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS
SMOKE II

SEX: FEMALE
EXPOSURE: 500 MG/M^3
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

ACCESSION NO.	DIAGNOSIS
78-929A	Tracheitis, multifocal, chronic, minimal, trachea, rat Bronchiolitis, granulomatous, focal, minimal, lung
78-929B	Interstitial pneumonia, focal, minimal, lung, rat
78-929C	Essentially normal tissues, rat
78-929D	Tracheitis, focal, chronic, minimal, trachea, rat
78-929E	Laryngitis, focal, chronic, minimal, larynx, rat
78-929F	Tracheitis, diffuse, chronic, moderate, trachea, rat
78-929G	Laryngitis, focal, chronic, minimal, larynx, rat
78-929H	Laryngitis, focal, chronic, minimal, trachea, rat
78-929I	Laryngitis, focal, chronic, mild, larynx, rat
78-929J	Tracheitis, multifocal, chronic, minimal, trachea, rat

PROTOCOL NO.: PEM 78-7 TABLE 10 MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS
SMOKE II

SEX: FEMALE
EXPOSURE: 500 MG/M^3
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

ACCESSION NO.	DIAGNOSIS
78-929K	Tracheitis, multifocal, chronic, minimal, trachea, rat
78-929L	Laryngitis, diffuse, chronic, minimal, larynx, rat
	Bronchiolitis, focal, chronic, minimal, lung

PROTOCOL NO.: PEM 78-7 TABLE 11 MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS
SMOKE II

SEX: FEMALE
EXPOSURE: CONTROL
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

ACCESSION NO.	DIAGNOSIS
78-930A	Histiocytosis, focal, minimal, lung, rat Chronic respiratory disease, minimal, lung
78-930B	Chronic respiratory disease, minimal, lung, rat
78-930C	Histiocytosis, multifocal, mild, lung, rat Chronic respiratory disease, lung
78-930D	Histiocytosis, multifocal, minimal, lung, rat Chronic respiratory disease, minimal, lung
78-930E	Histiocytosis, multifocal, minimal, lung, rat Chronic respiratory disease, lung

PROTOCOL NO.: PEM 78-7 TABLE 12 MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS
SMOKE II
SEX: MALE
EXPOSURE: 200 MG/M^3
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

ACCESSION NO.	DIAGNOSIS
79-15A	No significant lesions
79-15B	No significant lesions
79-15C	No significant lesions
79-15D	No significant lesions
79-15E	No significant lesions
79-15F	No significant lesions

PROTOCOL NO.: PEM 78-7
SEX: MALE
EXPOSURE: CONTROL
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

TABLE 13 MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS
SMOKE II

ACCESSION NO.	DIAGNOSIS
79-17A	Histiocytosis, focal, minimal, lung, rat
	Congestion, minimal, lung
	Chronic respiratory disease, minimal, lung
	Medial calcification, focal, minimal, pulmonary artery, lung
79-17B	Chronic respiratory disease, minimal, lung, rat
	Congestion, minimal, lung
79-17C	Pneumonia, granulomatous, multifocal, minimal, lung, rat
	Chronic respiratory disease, lung

PROTOCOL NO.: PEM 78-7 TABLE 14 MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS
SEX: FEMALE SMOKE II
EXPOSURE: 200 MG/M^3
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

ACCESSION NO.	DIAGNOSIS
79-16A	Histiocytosis, focal, minimal, lung, rat Pneumonia, interstitial, focal, minimal, lung
79-16B	Congestion, minimal, lung, rat
79-16C	Histiocytosis, multifocal, minimal, lung, rat Lymphoid infiltrate, focal, minimal, lung
79-16D	Congestion, mild, lung, rat
79-16E	Medial calcification, focal, minimal, pulmonary artery, lung, rat
79-16F	Histiocytosis, multifocal, minimal, lung, rat

PROTOCOL NO.: PEM 78-7 TABLE 15 MICROSCOPIC OBSERVATIONS IN RESPIRATORY TISSUES FROM EDGEWOOD AREA COLONY RATS
SMOKE II

SEX: FEMALE
EXPOSURE: CONTROL
AGENT: WHITE PHOSPHORUS/FELT
LENGTH OF EXPOSURE: 13 WEEKS
POST EXPOSURE: 30 DAYS

ACCESSION NO.	DIAGNOSIS
79-18A	Chronic respiratory disease, minimal, lung, rat
79-18B	Congestion, minimal, lung, rat

DISTRIBUTION LIST 6

Names	Copies
CHEMICAL SYSTEMS LABORATORY	
ATTN: DRDAR-CLF	1
ATTN: DRDAR-CLC-B	1
ATTN: DRDAR-CLC-C	1
ATTN: DRDAR-CLC-E	1
ATTN: DRDAR-CLJ-R	3
ATTN: DRDAR-CLJ-L	3
ATTN: DRDAR-CLT	1
ATTN: DRDAR-CLT-E	1
ATTN: DRDAR-CLT-P	1
ATTN: DRDAR-CLN	1
ATTN: DRDAR-CLW-C	1
ATTN: DRDAR-CLB-C	1
ATTN: DRDAR-CLB-P	1
ATTN: DRDAR-CLB-PA	1
ATTN: DRDAR-CLB-PO	1
ATTN: DRDAR-CLB-R	1
ATTN: DRDAR-CLB-TE	1
ATTN: DRDAR-CLY-A	1
ATTN: DRDAR-CLY-R	1
AUTHOR'S COPIES: Research Division	8
DEPARTMENT OF DEFENSE	
Defense Technical Information Center ATTN: DTIC-DDA-2 Cameron Station, Building 5 Alexandria, VA 22314	2
Director Defense Intelligence Agency ATTN: DB-4G1 Washington, DC 20301	1
Special Agent In Charge ARO, 902d Military Intelligence GP ATTN: IAGPA-A-AN Aberdeen Proving Ground, MD 21005	1
Commander SED, HQ, INSCOM ATTN: IRFM-SED (Mr. Joubert) Fort Meade, MD 20755	1
DEPARTMENT OF THE ARMY	
HQDA (DAMO-NCC) WASH DC 20310	1
Federal Emergency Management Agency Office of Mitigation and Research ATTN: David W. Bensen Washington, DC 20472	1
US Army Research and Standardization Group (Europe) ATTN: DRXSN-E-SC Box 65, FPO New York 09510	1
Commander HQ 7th Medical Command ATTN: AEMPM APO New York 09403	1
Commander USAOTEA ATTN: CSTE-ZX 5600 Columbia Pike Falls Church, VA 22041	1
OFFICE OF THE SURGEON GENERAL	
Commander US Army Medical Bioengineering Research and Development Laboratory ATTN: SGRD-UBD-AL Fort Detrick, Bldg 568 Frederick, MD 21701	1
US ARMY HEALTH SERVICE COMMAND	
Superintendent Academy of Health Sciences US Army ATTN: HSA-CDH ATTN: HSA-IPM Fort Sam Houston, TX 78234	1 1
US ARMY MATERIEL DEVELOPMENT AND READINESS COMMAND	
Commander US Army Materiel Development and Readiness Command ATTN: DRCLDC ATTN: DRCSF-P 5001 Eisenhower Ave Alexandria, VA 22333	1 1

Commander
US Army Foreign Science & Technology
Center
ATTN: DRXST-MT3
220 Seventh St., NE
Charlottesville, VA 22901

Director
US Army Materiel Systems Analysis
Activity
ATTN: DRXSY-MP
ATTN: DRXSY-T (Mr. Metz)
Aberdeen Proving Ground, MD 21005

Commander
US Army Missile Command
Redstone Scientific Information
Center
ATTN: DRSMI-RPR (Documents)
Redstone Arsenal, AL 35809

Director
DARCOM Field Safety Activity
ATTN: DRXOS-C
Charlestown, IN 47111

Commander
US Army Natick Research and
Development Command
ATTN: DRDNA-VR
ATTN: DRDNA-VT
Natick, MA 01760

US ARMY ARMAMENT RESEARCH AND
DEVELOPMENT COMMAND

Commander
US Army Armament Research and
Development Command
ATTN: DRDAR-LCE
ATTN: DRDAR-LCE-C
ATTN: DRDAR-LCM-SA
ATTN: DRDAR-PMA (G.R. Sacco)
ATTN: DRDAR-SCM
ATTN: DRDAR-SCA-W
ATTN: DRDAR-TSS
ATTN: DRCPM-CAWS-AM
Dover, NJ 07801

US ARMY ARMAMENT MATERIEL READINESS
COMMAND

Commander
US Army Armament Materiel
Readiness Command
ATTN: DRSAR-IRC
ATTN: DRSAR-ISE
ATTN: DRSAR-LEP-L
ATTN: DRSAR-SF
Rock Island, IL 61299

Commander
USA ARRCOM
ATTN: SARTE
Aberdeen Proving Ground, MD 21010

Commander
US Army Dugway Proving Ground
ATTN: Technical Library (Docu Sect)
Dugway, UT 84022

US ARMY TRAINING & DOCTRINE COMMAND

Commandant
USAMP&CS/TC&FM
ATTN: ATZN-CM-CDM
Fort McClellan, AL 36205

Commander
US Army Infantry Center
ATTN: ATSH-CD-MS-C
Fort Benning, GA 31905

Commander
USA Combined Arms Center and
Fort Leavenworth
ATTN: ATZL-CA-COG
Fort Leavenworth, KS 66027

DEPARTMENT OF THE NAVY

Commander
Naval Weapons Center
ATTN: Technical Library (Code 343)
China Lake, CA 93555

Commander Officer
Naval Weapons Suport Center
ATTN: Code 5042 (Dr. B.E. Douda)
Crane, IN 47522

DEPARTMENT OF THE AIR FORCE

HQ Foreign Technology Division (AFSC)
ATTN: TQTR 1
Wright-Patterson AFB, OH 45433

Commander
Aeronautical Systems Division
ATTN: ASD/AELD 1
ATTN: ASD/AESD 1
Wright-Patterson AFB, OH 45433

OUTSIDE AGENCIES

Battelle, Columbus Laboratories
ATTN: TACTEC 1
505 King Avenue
Columbus, OH 43201

Toxicology Information Center, WG 1008
National Research Council 1
2101 Constitution Ave., NW
Washington, DC 20418

US Public Health Service
Center for Disease Control
ATTN: Lewis Webb, Jr. 1
Building 4, Room 232
Atlanta, GA 30333